THE MANCHESTER ATHENÆUM.

During the last few years architectural design has much improved in our provincial towns, so that there are now many public buildings in almost all parts of the kingdom which would bear a comparison with those of the Metropolis. Liverpool and Manchester, as two of the most important towns, may be particularly mentioned.

In Liverpool there has been recently erected a well-designed structure in the Italian style of architecture, called the "Brunswick Buildings," of which a description and view will be found in the "Companion to the Almanac." To this and other fine buildings in Liverpool will be shortly added the St. George's Hall and Assize Courts, which, if completed according to the model, will be an unusually magnificent and imposing edifice. It is a classical Grecian design, with a façade, in the Corinthian order, of about the same extent as that of the National Gallery.

Manchester also possesses some buildings of more than ordinary interest, among which we may particularly mention two by Mr. Barry, the Royal Institution and the Athenæum. The latter is the subject of the engraving in our present number, and of its merits we need not speak, they will be sufficiently evident to every one. It is distinguished by a degree of gracefulness and simplicity not frequently so well united. It is more remarkable for the refined taste and artist-like spirit which it exhibits than for great invention or novelty of design. Mr. Barry, however, has a right to the honour of introducing into England this species of Italian architecture, in which the whole façade is treated as a single astylar ordinance, with a cornice in proportion. In all its leading characters this beautiful style is distinct from the Palladian, and it is still further removed from that which was in great vogue among us about half a century ago, and which was then, it may be supposed, considered as an improvement upon the modes it superseded. It has been considered necessary to treat the windows of every building as though they had no purpose in the general design, for they were not introduced as giving any architectural character, but simply as apertures to admit light, and for this reason every attempt at decoration was confined to the columns or pilasters, parts which are in general destitute of expression in themselves, serve to expose the poverty of a bad elevation, and make it more offensive to the man of taste. Architecture, as then practised, was founded upon erroneous principles, and, acting upon these, it was impossible for any man to produce a design to which more than negative praise could be given: imagination and refined taste could do no more than avoid some of the grosser faults. To produce a perfect design, the mind must be pre-occupied with correct principles. Every mode of building, worthy the name of an architectural style, has resulted from a desire to decorate, or render pleasing, the essential parts of the construction, and as those essential parts differ according to the climate of the country and the custom of its inhabitants, so a great variety of characteristic styles have been produced. Too often, however, even in the present day, this is forgotten, and the essential parts of a building are left in bald, unpleasing forms, that embellishments may be introduced upon parts which are altogether unnecessary, and are consequently deformities.

In the building which has given rise to these remarks, the windows, angle groins, string-courses, cornice, roof, and chimneys, are its decorations, and from these it obtains its architectural character. It is not, however, by the introduction of these features without regard to other considerations, that a pleasing design can be produced. The Athenæum of Manchester has great breadth and repose, which give it an air of dignity and importance; and it is worthy of remark, that the style cannot be satisfactorily adopted where there is not great space between the windows, and for this reason it is not suited, though chiefly remarkable for its simplicity, to our ordinary mode of building houses.

THE MODERN PRACTICE OF GOTHIC ARCHITECTURE.

NO. II.—THE ARCHITECTURAL SOCIETIES.

To the Editor.

Sir,—In the Notices to Correspondents in your last number, there is an Editorial promise "to examine the pretensions of the architectural societies at an early opportunity, and to bring before the profession and the public the objects they have really in view." This is one of the subjects upon which it was my intention to have addressed you, and as I am anxious for many reasons to have the opportunity of expressing my opinions, I avail myself of the earliest occasion of doing so, even at the risk of being considered somewhat impertinent in taking upon myself what you would certainly do much better. As men increase in age, they gain, or fancy they gain, a right to be heard upon subjects to which they have devoted their lives, and they are forgiven a loquacity which from others would meet with reproof.

The remarks you did me the honour to insert in your last number, have, I find, attracted some attention, and being much engaged with my professional brethren, I have had opportunities of hearing many opinions upon them. Some of your readers think they were too severe, and apply them personally to themselves, or to others, as best suits their humour; some have thought them calculated to do much harm by giving a feasible excuse for the establishment of clerical architectural societies, and a few, who have received them in the spirit in which they were written, have acknowledged the accuracy of the statements, and the baseness of the system they were intended to expose.

If any of your readers imagine that my essay was aimed at an individual, or that any of my observations were intended to have a private application, it is my duty to state decisively that they were not written with such an object. Should it be found that in the description of a system which has done more to injure architects and their art in public estimation, than any other cause, the proceedings in any one competition have been accurately described, and the parties who have disgraced themselves by unfairness, which is but another name for dishonesty, choose to apply my remarks, and consider them offensive, the fault is not mine. No great reproach could be fixed on me if I had even given you a list of all the dishonest competitions of the last ten years, with all their actors and circumstances, and this I could have done with but little trouble, but it has been my invariable practice to avoid speaking ill of any man, so that, if I cannot praise, I will not censure.

Having, I hope, set myself right with your readers upon one point of objection to my last communication, I will endeavour to meet the other—that by blaming the construction of many of the churches which have been built by the architects of the age, and asserting that they are for the most part destitute of taste, I tacitly encourage the pretensions of the architectural societies. This is not, surely, a logical or just conclusion. If I have blamed the ecclesiastical architecture of the age, I have traced the faults to their proper cause, and have defended the profession from the imputation thrown on it by the very existence of these buildings. But to assert that, because the present system is bad, the architectural societies are good, and that they ought in their present state, and with their present objects, to be encouraged, is leaping to a conclusion which I am never likely to reach.

As all the architectural societies are in connexion with the Camden, and boast that they are established for the same object, and on the same principles, one is saved much time and trouble in examining their several pretensions, for to understand the intended operations of all, it is only necessary to ascertain the objects of that one to which they are all allied, and the mode in which those objects are to be secured. Fortunately this can be done from the publications of the Camden Society, so that they may be judged by their own evidence.

The Address in the first number of the "Ecclesiologist," is sufficiently explanatory to prevent the possibility of doubting the intentions of the society, although that which the acting members could not but perceive would be offensive to the profession is stated in the least offensive manner. "It is intended," they say, "to give with each number, among other matters pertaining to Ecclesiology in general, critical notices of churches recently completed, or in the progress of building; to give publicity to projects of church building, or church enlargement, and thereby, it is hoped, to aid the erection or the endowment of the edifices in contemplation." So far no fault can be found with the objects,—they are commendable and useful; but it is added, "*to suggest, where it can be done without unwarrantable interference or presumption, alterations or improvements in the arrangements and decorations of new designs.*" Whether this passage be read with or without its saving clause, is a matter of small importance, for the acting members of the Camden Society will probably have a very different notion of what is unwarrantable interference or presumption to the architect in whose designs they are pleased to make "alterations or improvements in the arrangements and decorations." One is really delighted with the modesty of B. Webb, Esq., of Trinity College, and F. A. Paley, Esq., of St. John's College, Cambridge, the learned secretaries of the Camden Society, and the most learned council, that they should condescend to restrict their improvements to instances in which they are not in their own opinion guilty of unwarrantable interference or presumption. But who constituted these modest men the supreme judges of the excellence of ecclesiastical architecture? who gave them the title to interfere with the practice of an architect, and to force upon the public all the absurdities which they have adopted in the school of controversial divinity. Not one in a dozen of the acting members of the Camden society, could, three years ago, distinguish one period of Gothic architecture from another, and even now gain no more information from a working drawing than from an Etruscan inscription, and yet they have the daring, may I not be justified in saying the impudence, to assume the right of determining all matters of taste in ecclesiastical architecture, and of enforcing their dogmas upon men who have devoted years to the study, and from whose works they but yesterday acquired the superficial knowledge they possess. That men who have spent all their lives in the study of Greek and Latin, or of the mathematical sciences, with as much divinity as is to be found in the Tracts for the Times, should pretend to direct the architectural taste of the country, is an unparallelled instance of impudence and imposture, and must induce every one to believe that the Camden Society has some "ulterior though now hidden motives." Until these men are cured of their conceit, it is useless to recommend to their serious consideration the advice they have already so frequently read to little profit:—

> Qui semel adspexit, quantum dimissa petitis
> Præstent, maturè redeat, repetatque relicta.
> Metiri se quemque suo modulo ac pede, verum est.

One of the principal objects of the Camden Society, is, therefore, by its own confession, to interfere with the practice of the architect in church building, to exercise a censorship over his works, and to suggest alterations and improvements suitable to the dogmas and fancies of the secretaries and council. But although the truth has been told, the whole truth could not be confessed at once. The ulterior object is, to deprive the profession of the practice in ecclesiastical architecture, and to introduce the members of the Camden Society. There is in the church at the present time a fanatical spirit to restore all the ancient, obsolete, and in some instances anti-protestant practices of past ages, and among these we may find the erection of ecclesiastical structures by men in holy orders. When the architectural societies have gained a little more strength, this object will be boldly stated, and it will be asked, Who so fit to plan and construct a church as the priest who is to officiate in it? Then, and it seems not till then, will architects discover that in aiding and teaching the architectural societies, they have destroyed their own means of employment; and that to obtain support they must fall into the disgraceful position of superintending the plans of others, and performing the manual operations which their clerical masters have not the ability or the inclination to undertake.

That these societies are established for the purpose of inducing clergymen to become the architects to their own churches, is evident from the numerous works already undertaken by them, and the offers of assistance made to those who doubt their own skill. I would particularly call the attention of the profession to the following extracts from the first number of the Ecclesiologist:—

"In consequence of the fall of a considerable portion of this venerable and interesting church (St. Sepulchre's, Cambridge), a committee has been formed for its immediate and effectual restoration, consisting chiefly of members of the Cambridge Camden Society, *to which the direction of the works has been entrusted.* The architect, Anthony Salvin, Esq., is an honorary member of the society, and has presented his plans for *their* approbation."—Ecclesiologist, p. 5.

"*The Society has also furnished designs for a new church,* to be erected in the parish of Llantillio, near Ragland, South Wales."—p. 8.

"St. Nicholas, Old Shoreham, Sussex. Some account of the restoration of this church, *which was put under the direction of the Cambridge Camden Society* by the appropriators, the President and fellows of Magdalen College, Oxford, has been given in the first volume of the Society's Transactions."—p. 12.

"The church of Great Haseley, Oxfordshire, which must be well known to ecclesiologists from the interesting account which the Oxford architectural society has published of it, is undergoing a thorough restoration, *under the superintendence of that society.*"—p. 13.

"The church of Iffley, Oxfordshire, one of the finest Norman parish churches in England, is also being restored; and, judging from the prospectus, with excellent taste and feeling. *It is also under the care, we believe, of the Oxford Architectural Society.*"—p. 13.

I have here selected from the first Number of the Ecclesiologist no less than five instances in which churches are being restored or built under the superintendence or from the designs of the two principal architectural societies. If it were necessary, I could, by going through the succeeding numbers of that work, and the reports, find a hundred other instances in which they have usurped the duties of the architect, and forced the professional man into the condition of a clerk to their works. It is surely high time that the profession should shake off the bonds by which these societies intend to bind it. It has fallen into the snare, and the fetter has been insidiously placed round it, but it is not yet clenched. It may suit the convenience of a few architects to join these societies; it may, in a few instances, be a profitable

speculation, but if the profession have the courage to express through the medium of the public journals devoted to the arts its determination to oppose the unjust influence of the architectural societies, they will lose their power to injure, and become valuable auxiliaries in diffusing a knowledge of Gothic architecture, which is their only legitimate purpose.

But it is impossible to read the Camden publications without perceiving that the main object of the society is to restore to the church of England "tradition and ritualism." I will not follow the example of the society, and introduce religious controversies into the pages of your Journal, though, in fact, this is a principal objection to the architectural societies, and they can scarcely be exposed without some allusion to the subject. I will, however, only refer your readers to the article on "The arrangement of our Cathedrals," in the 16th Number of the Ecclesiologist, as an instance of the spirit which pervades the Camden Society. The motto of the Society is, "TRY," but try what? Whether the people will allow the clergy to exclude them from the choirs of our cathedrals as a place too holy for the laity, and seat them on benches in the nave.

"A glance into one of our cathedrals," says the Ecclesiologist, "as it was two hundred years ago, would probably scandalise some, and surprise more, of their frequenters at this day. No laymen admitted into the choir; the nave thronged with worshippers; the altar gorgeously arrayed with tapers and sacred vessels; the officiating priest vested in rich copes or chasubles; none presuming to cross the church without bowing towards the altar." All this mummery the Camden Architectural Society would restore in our Protestant cathedrals, and to all the "objections urged on the score of difficulty, dislike, unwillingness, inconvenience, impossibility," thinks it "sufficient to answer with the Cambridge Camden Society's favourite monosyllable, TRY."

The re-establishment of chantry services is also, I should imagine, another of the revivals of ancient custom which the Camden Society intends to Try. Permit me to call your attention to the following passage from the article on the brass to the memory of Lady Halsham, which may be read as a supplement to the scheme of turning out the laity from the choirs of our cathedrals: "It should be observed, that, along with the founder's name, mention was generally ordered to be made of the souls of all the faithful departed; and we may conceive how beautiful, in the stillness of an autumn evening, when the setting sun gleamed through the effigies of those 'merciful men whose righteousness hath not been forgotten, depicted on the stained glass of the eastern window—how beautiful and consoling must have been the chanted versicle—*Audivi vocem de cælo dicentem mihi;* and the response, *Beati mortui, qui in Domino moriuntur*:—how comforting in the misty darkness of a winter morning it must have been to see the gleam of the chantry lamp from the village church, and to hear on approaching the sounds of the morrow-mass—*Dominus, illuminatio mea, quem timebo? Dominus, protector vitæ meæ, a quo trepidabo?*"

It was to promulgate and establish these and similar Romish doctrines that the Camden Society was established, and churches are to be built or restored after the Camden models, to secure that object. If this were honestly stated, I should find no fault with the Society, or its members, but the insidious manner in which it attempts to controul architects, and disgrace them if they rebel, calls for exposure from one who, while he loves his art, would protect from imposition his professional brethren.

I am, Sir,
Your obedient servant,
B.

AGRICULTURAL DRAINAGE.

THERE is but one pursuit that has not in this country derived a great and direct benefit from the investigations of modern science, and that one is more important than all others—it is agriculture. In every manufacture mechanical and chemical knowledge has been applied to lessen the amount of manual labour, to economise the raw material, and to produce the greatest quantity at a minimum price. In agriculture there has been little improvement during the last half century, and, excepting the recent experiments upon manures, it might be almost said that there has been none. It is not that agricultural pursuits are of such a nature as to be less benefited by science than those of manufacture; it is not that the discoveries which have been made are less applicable to it, or that there has been a want of interest in the public mind. There is no branch of scientific investigation which does not admit of some application to agriculture; a multitude of chemical, mechanical and engineering principles calculated to improve its practice have been discovered, and no subject has so much engaged the public attention. But with all these advantages the farmer has been content to pursue the system adopted by his predecessors, and all offers of improvement have been received with so much indifference, if not contempt, that men have long since ceased to suggest those alterations in the culture of land which result from the constantly advancing state of scientific knowledge.

But the time has now come for the farmer and the landed proprietor to reconsider the important question of agricultural practice. The alteration already made in the Corn Laws, by which a portion of the protection hitherto enjoyed by the farmer has been withdrawn, and a diminution consequently produced in the value of agricultural produce, must compel him to inquire whether there is any means by which his land can be cultivated at a less cost, or be made more productive. The high price of corn has forced into cultivation a large extent of poor land, which has rarely produced a remunerating profit to the farmer, and which can now no longer be kept under tillage with his present resources. No portion of land, however, can be spared in a country which barely produces enough for the support of its population, and the cultivator will not readily relinquish that from which he may have a chance of profit, and upon which he has, perhaps, long been expending capital under the hope of future returns. The agriculturists view the future with fear, if not with despondence, and many are even predicting that the richest and most productive lands will scarcely repay the culture. Under these circumstances science offers its assistance with a greater chance of attention than it has yet received, and the art which has raised our manufactures and our transit to their present improved state, can effect a not less desirable change in the agricultural systems of the age. Should this assertion be proved, and it must be, or the landed interests of the country will not long retain their present station, the farmer will hereafter acknowledge that the alteration in the Corn Laws was the greatest boon ever received by the agricultural population from the hands of a government.

There are many ways in which engineering science may be applied with advantage to improve the present system of cultivating the land, but in none with so much certainty as in the establishment of a perfect system of drainage. The farmer is already convinced that some degree of drainage is necessary for the successful cultivation of his land, but the plans which he adopts are clumsy, expensive, and ineffectual; its importance is undervalued, and the mode is therefore a matter of comparative indifference. It will not, however,

be difficult to prove that it is indispensable to good farming, and therefore worthy of the most careful consideration; and this fact being established, some suggestions may be with confidence offered, and will, it is hoped, be examined with candour.

Of all the elements, water is not the least important in agriculture, while it is that one which is most under control. By a good system of cultivation the direct influence of solar heat and light may be preserved, but it is impossible to moderate or withdraw the power of either the one or the other. Injury they may therefore sometimes inflict without a possibility being left of moderating their direct influence. But there is an antagonist power, which, once brought under control, can prevent the evils which they may unitedly produce, and that agent is water. Concerning the nature of those agents usually called the imponderable, the present age is almost as ignorant as that which preceded it; their analysis is at this moment only commenced, and what may be effected during the remaining portion of the nineteenth century is but a matter of conjecture. But, although the nature of these principles is still unknown, their influence is better understood, and the means by which they act upon physical existence and organic structures: future discoveries may therefore enable the agriculturist to regulate their influence, and especially that important imponderable agent electricity, to an extent which cannot now be even conceived.

But, the element, which is and must always be the most important to the cultivator of the land, is perfectly under control, and may be made subservient to every purpose required. Man can neither augment nor diminish the quantity of water that falls from the clouds one drop, but he may prevent all the injury that would be produced by either excess or scarcity, and in this, as in a thousand other instances, control by intellectual energy the influence of natural agents. Whenever the farmer can be persuaded of this fact, the lapse of a few years will bring agriculture into a state which will bear a comparison with any of the mechanical arts.

It is not necessary for the present argument to show how surface water is vaporized and carried as an elastic fluid into the atmosphere; by what causes it is again liquified and brought to the surface of the earth in the form of dew, fog, rain, or snow; nor is it requisite to examine the causes which induce the fall of a larger quantity at one period of the year than another, nor to determine why a larger amount falls on highlands than on plains: it is sufficient for the immediate purpose of this essay to state the facts universally acknowledged, that its presence is indispensable for the successful cultivation of the land, whether arable or pasture, but that while in some instances injury may be done to a crop from its scarcity, an excess is equally injurious; while in some seasons vegetation may be scorched for want of moisture, in others it may become rotten from the abundance. If such a statement be acknowledged, it surely becomes a question of paramount importance whether some system may not be adopted by which these evils can be severally avoided.

To prevent drought and flooding, the present mode of farming pretends to find some corrective, by irrigation on the one hand and drainage on the other; but the ineffectiveness of the system is yearly proved by the injury done to crops by the casualties of seasons. The irrigation of pasture lands is in some degree attempted, but its incompleteness is well known to the farmer himself, though still more evident to the man who has informed himself of the system adopted on the continent, and more especially in parts of Italy. But it is not necessary to travel out of the country to see the advantages that would result from a more perfect system, for every plot of well-drained low pasturage sufficiently demonstrates the fact. The fault of a defective irrigation is not, however, always the fault of the cultivator, for the means are not generally at command.

Drainage, by which term is meant the art of carrying away surplus water that is not required to produce fertility, is even less understood than irrigation. The injury produced by want of it is not half estimated. When a larger quantity of water falls upon cultivated land than is required for the healthy growth of vegetable organization, a positive injury is produced upon plants, and disease is generated—thus far the effect of too great a supply is understood; but there are few persons who trace its effects upon the soil itself. In flowing over the saturated ground for any length of time, more positive injury is produced than by bearing one or two crops of corn. The particles of soil are disintegrated, the chemical compounds are more or less dissolved and carried away, and with them the finer parts of the earths. Hence it is that the detritus, or more properly the alluvial soils formed in low lands, by the flowing of water over the cultivated highlands or slopes, are so peculiarly rich and fertile.

It may then be taken as a maxin in agriculture, that the passage of water over the surface of the ground is injurious to the growing crop, and destructive to the fertility of the soil. The latter is of course least upon pasture lands, for the closeness of the vegetation has a conservative influence, and prevents the almost unopposed disintegration which is effected upon the lands under tillage.

If these statements be true, and they are equally evident to the practical agriculturist and the man of common sense, it will be asked by what means can all these surplus waters be carried off so as to prevent the flow over the surface? And to this the reply is at hand: By a judiciously planned and well-executed system of underground drainage. Stagnant waters are as injurious to vegetable as to animal life, and for the health of the one as well as the other they must be quickly carried away.

There is at the present time, in many instances, considerable difficulty in effecting a suitable drainage of land, so that the farmer is not always the person to be blamed for the want of this necessary arrangement. Where the waters are to be carried without injury to the adjoining land in the occupation of other persons, is frequently a problem that does not admit of a satisfactory solution, and this is one and almost the only difficulty in the gradual adoption of a general system of agricultural drainage, nor can it be removed except by legislative interference. How this interference is to be exercised the law must, and probably will at no distant period, determine. To compel every man, within a certain period, to drain his land would be as unjust in principle as injurious in practice; but, on the other hand, the inability or unwillingness of one person should not be allowed to prevent the improvements desired by another. The remarks made by Mr. Dean on this subject are judicious and worthy of attention:—"The drainage of estates for agricultural purposes," he says, "except by the owners and occupiers of the land, would, I am satisfied, never be authorized by parliament under any circumstances; but parliament may interfere to prevent negligent persons from causing direct injury to the lands of others; as, for instance:—You are the farmer of a considerable estate, capable of great improvement by under-draining, which you believe would, if under-drained, sub-soil ploughed, manured, and managed according to the most approved rules of good husbandry, grow at least half a quarter of corn per acre more than you now do, and consequently enable you to keep at least one-fourth part more cattle, sheep, and pigs, than you do at present, and that your landlord is quite willing to execute the drainage upon your paying him five pounds per cent. per annum on the outlay: but the outlet for the water from the drains is at one point only (and few

estates have more), viz. a small brook that enters and passes through an adjoining estate, the farmer of which is a sloven, and his landlord a careless, needy man, or may be that the estate is in Chancery, or belongs to a corporation, or to a charity, or to some incapacitated person, and that, therefore, the brook is choked with mud and weeds, so that the water from your drains could not pass away, and in consequence thereof you are unable to keep pace with the times, and the public is deprived of so much additional food. To say that parliament ought not to interfere in such cases (and there are thousands and tens of thousands of such cases), would be to libel the representatives of the nation, and would be an offence to common sense." There are, however, some instances in which the improvement of the outfalls would properly become a public duty, and be a national expence. It is not necessary to specify these instances in the present state of the question, but they will be properly defined by any commission that may be empowered to arrange and regulate the national sewerage.

It is not unworthy of notice, that if a general system of agricultural drainage should ever be adopted in this country, and the surplus water be judiciously conservated, a vast mechanical power will be obtained which is now entirely lost to the economical interests of the country. This power would be of the most important character, from the regularity with which it could be supplied, and the economy with which it might be appropriated. It would not be a difficult problem to form a proximate estimate of the mechanical power lost to the country from the want of agricultural drainage, nor to point out the advantages to many agricultural districts by the establishment of water-mills for various purposes, but the object of this essay is more to suggest subjects for consideration, than to trace them through the almost innumerable channels into which they flow.

Independent of the mere question of profitable husbandry, a judicious system of under-ground drainage would greatly tend to improve the condition of the atmosphere, making it more suitable to sustain vegetable life, and more healthy to men and animals. This view of the question is not applicable to every district, and there may be some persons who, residing in a country where the deleterious influence of a moist atmosphere is not felt, may doubt whether the argument is anything more than a means of accomplishing some favourite scheme, for the development of which every possible inducement is urged. But every man who is acquainted with the country must know numerous localities where disease and great mortality are prevalent in moist seasons, and be in possession of evidence sufficient to convince him that these are but the natural effects of a want of underground drainage. But to those whose knowledge is confined to their own locality, and who may be sceptical as to the unhealthiness of stagnant waters, the remarks upon the subject in the "*Report on the sanitary condition of the labouring population of Great Britain*," may be recommended for candid and careful consideration. The subject is not a novel one to the writer, but, from a long and careful consideration of facts drawn from every inhabited portion of the earth, he could show that the healthfulness of every district is mainly attributable to the disposal or neglect of surface water. But it is better to select one instance given by the commission, sanctioned, as the report is, in some degree, by the government, than to present a more extended but less authorized view of the subject. "In considering the circumstances," say the commissioners, "external to the residence, which affect the sanitary condition of the population, the importance of a general land drainage is developed by the enquiries as to the causes of the prevalent diseases to be of a magnitude of which no conception had been formed at the commencement of the investigation; its importance is manifested by the severe consequences of its neglect in every part of the country, as well as its advantages in the increasing salubrity and productiveness wherever the drainage has been skilful and effectual. The following instance is preserved by Mr. John Marshall, Jun., the clerk to the union in the Isle of Ely."

"It has been shown that the isle of Ely was at one period in a desolate state, being frequently inundated by the upland waters, and destitute of adequate means of drainage; the lower parts became a wilderness of stagnant pools, the exhalations from which loaded the air with pestiferous vapours and fogs; now by the improvements which have, from time to time, been made, and particularly within the last fifty years, an alteration has taken place which may appear to be the effect of magic. By the labour, industry, and spirit of the inhabitants, a forlorn waste has been converted into pleasant and fertile pastures, and they themselves have been rewarded by bounteous harvests. Drainage, embankments, engines, and enclosures, have given stability to the soil, (which, in its nature, is as rich as the Delta of Egypt,) as well as salubrity to the air. These very considerable improvements, though carried on at a great expense, have at last turned to a double account, both in reclaiming much ground and improving the rest, and in contributing to the healthiness of the inhabitants. * * The demand for labour produced by drainage is incalculable, but when it is stated that where sedge and rushes grew but a few years since, we have fields of waving oats, and even wheat, it must be evident that it is very great."

With reference to the mode of drainage, it is only necessary to remark that it must be planned from a consideration of the physical character of the district, for no spot can be considered isolated. Hence it is that engineering knowledge is indispensable. The system to be adopted for the drainage of the locality must be studied before it is possible to plan the drainage of any spot upon it, and that system must be the one so admirably suggested by Sir John Rennie for the Middle Levels,—"the improvement of the outfalls and channels of rivers; the judicious construction of inferior drains for lowland waters, and catch-drains for highland waters." These must be leading considerations in every survey.

Thus far the irrigation and drainage of land has been considered unconnected with any general system of sewerage, which the government of the country is as much bound to introduce from the necessity in reference to the health and economy of the country, as its own promise. But that measure, meeting, as it probably will, the expectation and wishes of the thinking men who have studied the question, will greatly aid the operations of the land-owner and agriculturist. Irrigation by pure water produces no positive benefit upon the land through which it flows, but is rather intended to prevent the injury which might arise from excessive heat. But if that water could be charged with substances which have an exciting influence upon vegetable life and growth, the irrigation becomes a system of liquid manuring. This might be made a means of mutual profit between the public and the agriculturist, in the same manner as the water-courses in Italy, while the more solid manures, which have an influence of longer duration upon soils when ploughed in, according to the English custom, would be of not inferior, and perhaps of greater value. This subject, however, comes more immediately under consideration in tracing the advantages that would result from a system of national sewerage.

But the farmer possesses many facilities for draining liquid manures as top dressings, though he takes little or no advantage of them. Farm-yard drainage would afford no inconsiderable an amount of liquid manure, and, if preserved, would often be invaluable, although it must be temporary in its effects, and has not the value of those which have more solidity. Mr. Denton's remarks on this subject are worthy of careful consideration:—"Although liquid manures as top dressings," he says, "either to land when naked, or when under growing vegetables, has little chance of being used in this country, excepting on a small scale, and

in garden work, where it is customary to manure once a year in order to obtain a succession of crops in that period, there are ways of applying liquid manure which are in accordance with our general mode of culture. The chief of these is as an ingredient in irrigation, though the British irrigator rarely uses manure in addition to the water he conveys over his meadows. As an ingredient, this liquid manure is very valuable, at least, in stimulating a healthy and abundant crop the first year of its application, and it is not preserved and managed in the ratio of its value in this way. The liquid manure of the cattle shed, and the more liquid part of such manures as are procurable in towns, are the ones principally useful. The farm-yard portion may be obtained without being at all mixed with the more solid parts, or it may be left with these for a time, and then drawn off, having enriched the straw and other undecomposed parts of the manure, and being itself enriched by other portions of the same manure dissolved in it. In either of these ways it should be conveyed in under-ground drains, where not too expensive, to the tanks or reservoirs from which the irrigation is to be supplied. The more liquid part of the town soil ought to be removed much in the same manner, only diluted with water when that appears necessary. The same tanks which receive these are also to receive the surface and drainage water, conveyed in covered drains from the higher grounds. This last will be more or less loaded with alluvial matter, washed down from the said grounds, and the nature of this matter with that of their soil, and may be loam, clay, sand, or pulverized chalk or limestone, or whatever ingredient the soil upon the higher grounds may have upon the surface, so as to be easily washed down by the rains. These are almost the only admixtures of the water now used in British irrigation, but combining them with manure, in the way that has been stated, would add much to their value, and that at very little expense. The manure would act as an immediate stimulus to the grass, and the alluvial matter would increase the richness of the soil and add to its permanent fertility; a judicious mixture of the two would thus form the *ne plus ultra* of British irrigation upon all lands to which it could be applied."

Innumerable instances of the successful application of drainage and irrigation might be mentioned, but it will be better to mention one that has been already published and is well authenticated, than to describe others less perfectly known, and which might be undervalued from a supposition that they were unfairly stated. The Teddesley Hay estate is the property of Lord Hatherton, and previous to its drainage, the total rental was £254 10*s.* 9*d.*: it is now £689 13*s.* 1*d.* A mill also has been erected which is turned by the drainage water, which, after performing that work, is carried into a tank where the farm yard drain also terminates. From this tank eighty-nine acres of upland meadow lands are irrigated, upon which there has been an improvement equal to two pounds per acre of annual rental. The total cost of these works was £2,733 2*s.* 2*d.*, the total annual increased value £1,013 2*s.* 4*d.* When such facts as these become generally known to agriculturists, an improved system of drainage and irrigation cannot be far distant.

ON THE EFFICACY OF STEAM AS A MEANS OF PRODUCING ELECTRICITY, AND ON A CURIOUS ACTION OF A JET OF STEAM UPON A BALL.

BY W. G. ARMSTRONG, ESQ.

(From the "Philosophical Magazine.")

The experiments which I have made on the electricity of steam since the date of my last communication to the "Philosophical Magazine" have completely confirmed the conclusion which I then arrived at, that the excitation of electricity takes place at the point where the steam is subjected to friction, and by the improvements I have effected in the mode of discharging the steam, I have so amazingly increased the energy of the effects, that I question whether any electrical machine has yet been constructed capable of producing as much electricity as my electrical boiler. At all events, the boiler has been proved to possess upwards of seven times the efficiency of an excellent machine which has a plate of three feet in diameter, and which was worked at the rate of seventy revolutions in a minute when its power was tried. The comparison was made by means of a discharging electrometer, and the following tabular statement will convey some idea of the quantity of electricity produced in each case.

Capacity of the jar of the electrometer, half a gallon nearly.

Extent of coated surface on the two sides, taken together, 198 square inches.

Distance of the balls of the electrometer from each other, one-third of an inch.

Number of discharges obtained per minute when the instrument was connected with the prime conductor of the machine, 29.

Number of discharges obtained per minute when it was applied to the insulated boiler, 220.

The discharges were so exceedingly rapid when the electrometer was connected with the boiler, that it was difficult to count them with accuracy, but the number I have inserted is assuredly not overstated.

The boiler is a wrought-iron cylinder with rounded ends, and measures three feet six inches in length, and one foot six inches in diameter. It rests upon an iron frame containing the fire, and the whole apparatus is supported upon glass legs to insulate it. The application of the fire is unfortunately very imperfect, in consequence of which the boiler will not maintain for any considerable time the discharge of steam which is requisite to produce the effects I have mentioned; but a short interval of quiescence suffices to restore the pressure, and to render the boiler again ready for action.

It is much more convenient and effectual to collect electricity from the boiler than from the steam-cloud, but in order to obtain the highest effect from the boiler, the electricity of the steam must be carried to the earth by means of proper conductors.

Notwithstanding the enormous dissipation of electricity which is occasioned, when the tension is great, by the dust and effluvia of the fire, and by the angular parts of the apparatus, I can draw sparks twelve inches long with great rapidity from the rounded end of the boiler; and if a projecting ball of proper dimensions were attached to the apparatus, much longer sparks would probably be obtained.

I find it essential to a high development of electricity, that the steam should be discharged with a slight intermixture of water, although, from a cause which it is needless to explain, this did not appear to be the case in the experiments which I formerly made with a gun-metal generator.

A piece of hard wood, such as ebony or partridge wood, is the best material I have yet tried in which to make the discharging passage, but it is chiefly by prefixing to the wooden channel a brass cap of very peculiar construction that I have been enabled to obtain the present powerful effects. The piece of wood containing the discharging passage is, for the convenience of fixing, formed into a plug. The brass cap to which I have alluded, is affixed to the smaller extremity of the plug. The steam passes, in the first instance, through a lateral

slit or saw-cut in the brass about one-thirtieth of an inch wide, then through a circular hole in the centre of the cap, about one-tenth of an inch in diameter, and, finally through the wooden channel, from which it is ejected into the air. The pasage through the wood is of a cylindrical form, and of somewhat larger diameter than the circular hole in the centre of the brass. A stop-cock is attached with a socket to receive the plug, which is kept firmly down by a screw nut at the top.

Several cocks of this description, each fitted with a wooden plug such as I have described, are screwed into an iron vessel communicating with the boiler, and in which the proper quantity of moisture to be carried out with the steam is deposited by condensation. The steam is used at a pressure of about seventy pounds on the square inch, and is discharged horizontally in diverging jets. Each jet affords quite as much electricity as a good electrical machine of ordinary dimensions; and when it is considered that a boiler of evaporating power equal to that of a locomotive engine would be adequate to sustain hundreds of such jets, an idea may be formed of the prodigious evolution of electricity which it is practicable to obtain by the agency of steam.

Although it is perfectly clear that the electricity is excited in the discharging passage, where the steam is exposed to violent friction, yet, as the mode of ejection which I have described is neither characterized by peculiar violence of friction, nor by great extent of rubbing surface acted upon by the steam, I feel great difficulty in accounting for its extraordinary efficacy, upon the supposition that friction is the exclusive cause of the excitation.

In the course of my experiments, I have observed a very singular effect of a jet of steam, which, as far as I am aware, has never been noticed in any publication, and which I therefore take this opportunity of mentioning, although it is quite unconnected with electricity.

If a ball be immersed in a vertical jet of high-pressure steam, the ball will remain suspended in the jet, without any other support than it derives from the steam, and if it be pulled to one side by means of a string, a very palpable force will be found requisite to draw it out of the jet. The experiment may be varied, and rendered exceedingly striking by discharging the steam obliquely, in which case the ball will take up its position at a greater distance from the orifice, but will still be sustained in the current, notwithstanding that gravity in this instance acts at an angle to the jet. A hollow globe made of thin brass, or copper, and from two to three inches in diameter, answers very well for the purpose, where the steam is discharged from an aperture not less than 1-20th of a square inch in area.

In the well-known experiment of supporting a ball upon the summit of a jet of water, the ball merely reposes in the hollow formed by the liquid in the act of turning over to fall to the ground, which is very different from being sustained in the current, as it is in the case of steam.

ABSORBENT ARTESIAN WELLS.

The operation of boring into the permeable strata of the earth has been long employed for the supply of water, but a novel application of boring is now being tried in various parts of France, within the circle of the Paris basin, and, in almost every case, they have been successful; it is that of making an Artesian well the means of carrying off the waste water where there is not sufficient drainage; from this practice some very interesting facts have come to light. A manufacturer, for instance, in the Faubourg St. Marceau, endeavoured to get rid of the waste water from the engine by sending it into an old well which was not used; for a length of time this produced no inconvenience, but, after the lapse of a few months, the water in the neighbouring wells became so warm as to be quite useless for general purposes, and he discontinued the practice in consequence; it was then eighteen months before the water in the wells got back to its original temperature. As long ago as 1790, the Hospital of Bicetre has been divested of its waste water, by being turned into some old quarries in the neighbourhood; to obtain a perfect infiltration, the architect dug a well forty-five feet deep from the bottom of the quarries, and this has ever since carried off all the waste liquid; all the wells in the immediate neighbourhood are, however, in some degree affected by it; and, in several cases, parties have sunk their wells into the next permeable strata to prevent the water being infected. From the experiments which have taken place, the most important results are anticipated in an engineering point of view; marsh land may be drained by these means, and thus rendered productive; and it is suggested that London, and the whole of its environs, might be drained by absorbent Artesian wells, and the water of the Thames thus left perfectly pure; there is no doubt but such a plan, if adopted, would conduce much to the improvement of the public health; and it is considered by scientific men that the water, by its filtration, loses the greater part of its impurities, and that water from wells, in many cases even in the same strata that drainage water is turned into, will be quite clear and wholesome. Connected with this subject, is the temperature of water at various depths. Dr. Paterson has made a series of experiments on the wells of Mid-Lothian, Stirlingshire, and Clackmannanshire, from which the following results are arrived at:—

	Ft. deep.	Temp. Fahr.
A well in the parish of Slamannan . .	180	48
A spring at Kennetpans	160	49
Ditto at ditto	210	51
Ditto at Kerse	231	51½
Ditto at Kennetpans' distillery . . .	270	51½
Ditto at Mr. Bruce's house, at Kennetpans .	350	53

From these and a variety of other facts of the same nature, which have been noticed in various parts of the world, the average rate of increase appears to be 1 deg. Fahrenheit for every 53·1 feet in depth, while the average of the springs noticed by Dr. Paterson, in Scotland, is 1 deg. for 47·11 in depth.—*Mining Journal.*

AN ACCOUNT OF THE CONTORTIONS AND FAULTS PRODUCED IN THE STRATA UNDERNEATH AND ADJACENT TO THE GREAT EMBANKMENT ACROSS THE VALLEY OF THE BRENT ON THE GREAT WESTERN RAILWAY

BY J. COLTHURST, ESQ.

(From the Proceedings of the Geological Society.)

The author was induced to lay this paper before the Society, because he conceives that, in the phenomena exhibited by the subsidence in the Brent embankment, there may be found the cause of many of the contortions, faults, and dislocations of strata, especially among

sedimentary rocks, and which are commonly attributed to the agency of forces acting from below, rather than to pressure from without.

The embankment is fifty-four feet in height, and rests on vegetable soil, beneath which are four feet of alluvial clay; then occurs a bed of gravel, varying from ten to three feet in thickness, but which thins out in some places, and under it is the regular London clay, traversed in almost every direction by slimy joints. The surface of the country gradually slopes towards the Brent, the difference of level between the south side of the embankment and the Brent being about twenty-feet.

On the night of the 21st of May, 1837, the embankment began to settle, and in the morning it was found that the foundation had given way, and that on the south side, or towards the Brent, a mass of ground, fifty feet long and fifteen feet wide, had protruded from under the earthwork. During the four succeeding months, this mass continued to increase in dimensions, and the disturbance to extend, so that the surface, for a considerable distance from the base of the embankment, had assumed an undulated outline, and the subjacent beds, where cut into, exhibited corresponding curvatures, overlappings, and cracks, the whole of which are described in the memoir, but cannot be rendered intelligible without diagrams. In the embankment itself, the symptoms of failure were confined to a settlement of about fifteen feet, and a large fissure near the top, on the side opposite to that where the foundation has yielded, and which extended the whole length of the slip. To this fissure and its dip towards the disturbance at the base of the embankment, the author particularly directs attention, as he infers from it the nature and inclination of a fault exhibited in the diagrams which illustrate the memoir.

At the end of twelve additional months, during which the embankment continued to slip, and the disturbance at the base to increase, Mr. Brunel directed a supplementary earthwork or terrace to be thrown down upon the swollen surface, and it was an effectual remedy. Up to this time, the total subsidence had exceeded thirty feet; and the swollen ground, which extended nearly 400 feet in length, and from 70 to 80 feet in width, had attained an average height of 10 feet, with a horizontal motion of 15 feet; but the general disturbance ranged to a distance of 220 feet from the foot of the slope, or to the Brent, the bank of which was forced five feet forwards; the faults varied from 30 feet to 2 feet, and the contortions had attained a curvature, the semi-axis of which was in many places 8 feet.

The author then dwells on the magnitude of the disturbance, and on the effects which may have been produced in the strata composing the earth's surface, by pressure from above. He says, that, in consequence of the great inequality in the thickness of the sedimentary rocks, due to the conditions under which they were deposited, great inequality of pressure must have arisen, and consequently contortions and faults have been produced, varying in amount according to the thickness and the degree of consolidation in the strata themselves. In support of his argument, the author quotes a passage contained in Mr. Greenough's "Critical Examination of the Principles of Geology," and which asks the question whether contortions may not have taken place where clay alternates with limestone or silex, in consequence of an unequal rate of consolidation (p. 77). The author also alludes to the theory of Sir James Hall, but chiefly to prevent its being "mixed up in any way with the subject of this paper, or the inferences it contains;" and, lastly, he wishes it to be clearly understood, that while he advocates the explanation of many geological phenomena, by means of pressure from without, he does not propose that all geological disturbance should be attributed to it, nor does he deny that many, and more especially the most considerable irregularities in the structure of the earth, may and must be assigned to other causes.

THE DRAINAGE OF THE MIDDLE LEVEL.

Two very important Reports, one by Mr. Walker, and the other by Sir John Rennie, upon the Drainage of the Middle Level, have recently appeared, and as they are documents worthy of preservation and valuable for reference, we have thought it desirable to introduce them into our Journal. As they occupy several pages, we are prevented from making extended remarks upon them at the present time, but we cannot allow them to appear without briefly recording our opinions. It would be injudicious and rash for any engineer, even if he had before him all the Reports that have been written on the subject, and accurate details, to give a decisive opinion upon the propriety of adopting any one plan as being the best that could be devised, but it would be quite within his power to determine which was best supported by sound principles of science, and to compare one suggestion with another. This is all that we shall pretend to do, nor can we be deterred from this by the acknowledged discernment and experience of the engineers whose Reports are before us. We know of no authorities in either science or art, and great names can only command attention when they designate great minds.

Mr. Walker's Report makes its appearance with many disadvantages. It is loosely and carelessly written, in a style which would ensure a school-boy a sound flogging; it is wanting in clearness and logical connection of the parts, and it is not founded on any comprehensive scientific principle. We regret that the Report should be open to such a censure, for it must have required much higher faculties of mind than can be traced in this document to have raised Mr. Walker to his high station among the engineers of the country. The plan he suggests for the drainage of the Middle Level essentially consists in the formation of a new straight drain, "made so low as to be entirely under such of the present rivers and drains as are navigable; these rivers and drains being carried over and across the new drain in cast-iron aqueducts, for the purposes of navigation and the supply of fresh water for the land and for cattle." This recommendation he supports in another part of his Report by the following statements:—"Navigation prefers an uniform level of water at all seasons; lands require it to be kept down to the lowest level in wet seasons. Here, on principle, the two do not agree; and when, as in the present case, the established or lowest navigation level is above the average of all the land, and some feet above a portion of it, the principle becomes powerfully illustrated." With Mr. Walker's principle we cannot agree, for by doing so we should be driven to the conclusion that navigable rivers are improper outlets for surface drainage; and that when the lowest level of navigable water is above the natural level of the district through which it flows, there is no other means of effectually correcting the evil but that of cutting a new straight drain to receive the surplus waters: we cannot give our assent to either of these propositions.

An ordinary report, embracing any sound principle of science, would have received additional interest by being contrasted with Mr. Walker's distressing failure. But Sir John Rennie's Letter to the Duke of Bedford is not a common performance. It is written with great ease and perspicuity, and takes so enlarged a view of the entire subject of drainage, that no man, however ignorant of the subject, can attentively read it without being fully prepared to exercise an independent judgment, and to gain information from the experience and opinions of others. To the civil engineer it is especially valuable as a digest of the entire art of drainage, and of the most prominent

scientific truths on which it depends. In one paragraph Sir John Rennie has clearly stated all the great leading principles of successful practice;—"As the natural tendency of the outfalls or mouths of rivers and channels is to decay, the first object of engineers has been to remedy these defects, and, by regulating the natural channels, to render them more effective for the discharge of their waters. The next, to conduct the surface waters from the adjacent lands by means of artificial channels or canals, in as direct courses as practicable, in order to economise the natural fall or inclination, and to enable them to be discharged into the main rivers at the most convenient points; it being justly conceived, that the more the natural courses of the rivers can be used the better, as saving the needless expense of making and maintaining two channels, and that the greater the quantity of water that can be made to pass through one channel, the greater will be the certainty of keeping that one open.

"In addition to these two grand and fundamental principles of drainage, my father, who adopted them generally both in theory and practice, introduced a third, almost equal in importance to either of the other two, namely, the *catchwater drain*."

We shall, on an early occasion, again refer to this subject, and present our readers with the report of the late Mr. Rennie in 1810, and those of Sir John Rennie in 1836 and 1839, with a map of the district, showing the various lines of drainage which have been proposed.

REPORT ON THE DRAINAGE OF THE MIDDLE LEVEL, PART OF THE GREAT LEVEL OF THE FENS, CALLED THE BEDFORD LEVEL, AND ON THE STATE OF THE RIVER OUSE, BELOW DENVER SLUICE, IN REFERENCE TO THE DRAINAGE OF THE SOUTH LEVEL. BY JAMES WALKER, F.R.S., L. & E., PRESIDENT OF THE INSTITUTION OF CIVIL ENGINEERS.

To the Proprietors of Lands in the Middle Level of the Great Level of the Fens, called the Bedford Level, on the drainage of the Middle Level, and on the River Ouse, below Denver Sluice.

THE Report commences by stating that it was made in consequence of a resolution passed at the meeting of the Bedford Level Corporation, in April last, when it was ordered that the engineer be instructed, "to direct his attention to the state of the river Ouse, below Denver Sluice, with a view to consider whether any, and what improvements can be made in that river, to render it more effective for the drainage of the Middle and South Levels." And that at a meeting of proprietors of lands in the Middle Level, held at Chatteris, on the 22nd day of the same month (April), Mr. Walker was appointed, and was "to have regard to the effect which the measures he might recommend would have upon the navigation, and to deliver his Report in sufficient time to allow of parliamentary proceedings being taken in the next session." A committee of the Bedford Level Corporation was appointed, and several meetings held, at which the solicitors, Mr. Archer and Mr. Day, were present, as well as the register, Mr. Wells, and finally it was left to Mr. Walker to take, without limitation, as large a view of the rivers, and of the subject, in all its bearings, and of the various schemes that have been suggested, as he might consider requisite for enabling him to propose "the most effectual measure for the better drainage of the Middle Level, having regard to the navigation within that district," and the other collateral interests that might be thereby affected.

REPORT.

Survey and Levels.—It is almost unnecessary to say, that although the extent of the surface is a great many miles, a few feet or even inches vertically may influence the question of drainage; and as a perfect agreement did not exist in the levels that had been taken at various times, previously (arising, probably, more from alterations in the levels by new works, and from the levels being taken in different states of the rivers, than from incorrectness,) an entirely new survey, particularly as respects levels, became indispensable. This I entrusted to Mr. Comrie and assistants, and they were not completed till the end of July. While they were in progress, and since, I have on several occasions surveyed the rivers and the districts drained by them. My partner, Mr. Burgess, has also at my request made a similar survey, and assisted me in the consideration of the various schemes brought under my notice, and of that which I shall recommend.

Boundary.—The Middle Level of the Fens, consisting of about one hundred and forty thousand acres of land, is bounded by Moreton's Leam, which divides it from the North Level, on the west; by the Wash between the Old and New Bedford or Hundred-foot River on the east, by the high lands between Peterborough and Earith on the south, and by Marshland on the north.

Defective State of the Drainage.—With the exception of some high land round Whittlesey, March, Doddington, Chatteris, and Ramsey, and some other small pieces, the whole of this great area, and also of Marshland, which is as low as the Middle Level, is dependent on artificial means (steam and wind engines) for drainage. This has arisen partly from the lowness of the ground, which even in the present improved state of the Ouse by the Eau Brink Cut, is in the lowest parts four feet below, and on the average of the whole Fen, one foot below the level of low water in times of floods in the River Ouse at Tongs Sluice, the lowest, and at present by far the most important drain of the Level. It has arisen, also, partly from the internal rivers not having been adapted to the improved state of the Ouse, and partly from the navigation levels having been fixed too high to allow advantage to be taken of the recent improvements for drainage. When the water, even in the great river or outfall, is thus locked up, it is evident that the interior can have no drainage; it may be pumped from the fens into the drains, until it flows back over the banks, for which even steam power affords no relief; or in case of a want of wind for the wind engines, it must remain upon the land, and may damage it for years, as well as perish the seed or the crops. A practical proof of this was given last winter, when the water in all the internal rivers was for a month kept up ten feet above the level of low-water at the same time in the Ouse, at the Eau Brink Cut. The navigation and the drainage being in the same channel, increases the evil. In heavy floods, as will afterwards be shown, it takes considerable time for the water at the upper end of the district to reach the outlet at the Tongs, arising, firstly, from the restriction to drawing, even at such times, below the navigation level, near the outlet, so that the sluices are obliged to be immediately shut down, without regard to the drowned state of the distant country; secondly, from the communication with the river Ouse being so far up as the Tongs, where the low water, in floods, is seven to eight feet above the low water at Lynn, and six feet above the low water at Marshland Sluice, and lastly, from the small size, crookedness, and foulness of the drains. The damage to the Middle Level by last winter's floods alone, is stated to have been most serious in amount.

Opinions of Engineers.—Mr. Rennie.—In his great Report for the improvement of the Bedford Level, dated 1809, Mr. Rennie proposes the following for the Middle Level only:—

First. A catchwater drain from Monk's Wood to Standground, and from the same point to Earith, falling each way in order to intercept the water from the high lands, and carry it into the Ouze and the Wisbech river, or New Nene. *Second.*—A sluice of fifty feet waterway near the head of the Eau Brink Cut, on the west side of the river, and from thence a new drain of fifty feet bottom, in a straight line to the Old Bedford river, crossing the Tongs, Salter's Lode, and the Old Bedford, and joining Popham's Eau, which, from this point of junction, was to be improved, as well as the Old Nene and Whittlesey Dyke, up to Standground Sluice; also, Bevill's Leam up to Whittlesey Mere, and the Old Nene up to Ramsey and Ugg Meres; but, Mr. Rennie adds, "that as the Old River Nene is very crooked, and as the expense of making it of sufficient capacity to receive the water which would drain through it will be great, it would be better than improving the old rivers, to make a new cut in a straight line from Popham's Eau to Whittlesey Mere." *Third.*—The Old Bedford, the Forty-foot, and the Sixteen-foot rivers, were to be scoured out, deepened, and enlarged. It appears from the plan and the above description, that the water in Mr. Rennie's proposed new cut, from Popham's Eau to Whittlesey Mere, was to be on the same level, and to communicate with the Sixteen-foot and Forty-foot rivers; the same channel thus serving for navigation and drainage. Mr. Rennie considers that by the above, "the Levels would be effectually drained." His estimate for the works he proposes for the Middle Level is £252,000, exclusive of the new drain to Mepal.

Sir John Rennie.—The scheme that appears next in order, but which embraces only a part of the Middle Level, is that of Sir John Rennie, as detailed in his report, dated December, 1836. This plan proposes, by means of an effectual improvement of the Nene through Wisbech, and other minor improvements above and below that town, to adapt the river Nene for the navigation of sea-going vessels up to Peterborough. The effect of these improvements in lowering the water, when the tide is out, is supposed to be such, that by continuing the Twenty-foot river to join the Nene at Guyhirn, with a new sluice at the junction, and to join Bevill's Leam at the other end, and by deepening and widening the Twenty-foot river and Bevill's Leam to the junction with Whittlesey Mere, and across the Mere up Caldecot dyke, fifty thousand acres of the Middle Level might be drained by natural drainage, as the North Level is stated to have been by the New North Level drain. The portion so

to be drained is between Moreton's Leam Wash and the old Nene, bounded on the west by the high lands near Stilton, and on the east by the turnpike-road from March to Wisbech, including Whittlesey, Ramsey, and Ugg Meres. The deepened drain would, it is said, be carried under Whittlesey dyke, which it would cross at Angle bridge, by means of a syphon culvert. Sir John adopts his father's plan of a catchwater drain from Standground Sluice to Monk's Lode, for the purpose of preventing the high land water from the vicinity of Yaxley, Stilton, and Ramsey, from coming into the low lands, and another catchwater drain from Monk's Lode into the Old Nene, near Ramsey. He estimates the work at £120,000.

Messrs. Little and Humann.—In 1841, Mr. Joseph Little and Mr. John Humann surveyed and levelled the internal rivers and drains of the Middle Level, with a view to the improvement of the drainage, and deposited plans preparatory to an application to Parliament. The main feature of their scheme is a very great enlargement and deepening of the present internal rivers and drains. They begin from the lower end of the Tongs Drain, where their bottom depth was proposed to be two feet above the sill of the sluice, or two feet one inch below zero on the Lynn Free Bridge index; and from thence they rise gradually at the rate of two inches per mile, through the rivers and up to Whittlesey Mere, which, with the other Meres, is proposed to be drained. The deepening of the present drains, in order to attain the above levels, varies from three to nine feet, the bottom width of the deepened drains varying from ten to fourteen feet, and the width at top in proportion. They also propose, as a great improvement, the junction of the Forty-foot drain and the Sixteen-foot river. Their only new cut was one of four miles and a half in length, in a straight line from the Old Bedford to Well Creek, at Nordelph, (the upper Tongs Sluice). Through Outwell and Upwell, where so great an increase of depth would be objectionable, the navigation was proposed to be kept up by means of a "pen lock," and the present circuitous course of drainage through these towns to be avoided by being taken through Popham's Eau.

Mr. Mylne.—Mr. Mylne, in two reports to the committee of the Middle Level, approves, with modifications, the scheme of Messrs. Little and Humann as preferable to the Nene or Guyhirn plan, and recommends that the sills of the outlets of the Old Bedford and Salter's Lode be lowered.

Mr. Laurance.—The next scheme that I consider it necessary to name, is that of Mr. Laurance, engineer and surveyor to the earl of Carisfort, and to Mr. Wells, of Holme, the principal owners of the Whittlesey and Trundle Meres, on whose behalf his attention was, I presume, first turned to the subject of this drainage. Mr. Laurance has kindly sent me a copy of his plan, sections, and report. He abandons Popham's Eau and the Tongs, and adopts the New Marshland sluice and drain as his outfall into the sea, with some small improvements in its course, for a length of two to three miles up to Emneth Hungate, whence he proposes a new cut, eight miles in length, through Emneth Fen, and under the Wisbech Canal, a mile west of Outwell, to Laddus Mill; another plan carries this new cut to the head of Popham's Eau, where his new cut joins the Old Nene, from which point of junction he proposes another new cut, two miles in length, to the Sixteen foot river, for conveying its waters into his new drain. In case of objection to the above, on the part of Upwell and Outwell, Mr. Laurance proposes a modification, by which his new Marshland cut would join the old river at the north end of Outwell. The other drains he proposes deepening and enlarging, on the same principle as that of Messrs. Little and Humann, already described. The future navigation level in the drains was to be four feet lower than the present.

Mr. Samuel Wells.—The last in point of date is proposed in a pamphlet by the present register, Mr. Wells, whose long and intimate knowledge of the Fens, and the Fen laws, entitles his opinion to consideration. For the Middle Level, he also proposes the enlarging of the present rivers, including the Tongs Drain; that there should be one concurrent drainage for the Middle Level; that the River Nene Act should be repealed, and the navigation placed under commissioners. For the benefit of the south Level, he advises, amongst other works, that St. John's Eau be restored and carried to its original outfall; and, for the benefit of both Levels, he recommends cutting off Magdalen Bend, and making a cut from Lynn Harbour across the estate of Lord George Bentinck to the outfall at sea.

Remarks on Plans.—Having named the various schemes, I may state that any of them would be productive of great benefit. Those that contemplate the deepening and improving the present drains, would allow the flood and pumped water to get down freely to the outlets, which the present narrow, crooked, and in some cases foul state of the drains prevents.

Mr. Walker then speaks of the various plans, to all of which he objects.

Mr. Rennie.—The only scheme on which I have not offered any observation, is that of the late Mr. Rennie, which approaches more nearly than any of the others to what I have to propose; so that I have, in some respects, the sanction of his high authority, and as I find that in giving my own opinion I shall have to refer to his, I defer, for the present, any observations upon this plan.

Levels and Gauges.—As the levels have been taken with great care, and I doubt not correctness, it may be proper that I state here the comparative levels of the Nene Outfall and the Eau Brink Cut, as they appear on the sections; and as they may not agree precisely with former levels, it is right to name, as one of the causes, an error in the Lynn Free Bridge gauge, which was not discovered till the discrepancy in Mr. Comrie's work led him to suspect that something was wrong. The divisions on the board were each one foot, without any allowance for the sloping of the pile of the bridge to which it was attached. This caused an error of five inches, nineteen feet measured on the sloping line being vertically only eighteen feet seven inches. The difference has heretofore been erroneously ascribed to a sinking of the pile to which the board was attached. A new board has been fixed, the zero point being the same level as that of the old index, and this zero point has been taken as the datum level of my survey, and of this report. When put up at the finishing of the bridge, zero upon it was, I am informed by Mr. Townsend, the then resident engineer, the level of average spring tides at this place. The observations of three springs, made in May and June last, make low water one foot above datum or zero, which agrees with five years' observations made by Mr. Merry, the superintendent of the Eau Brink works. Corresponding tide gauges from the same datum level have been fixed by Mr. Comrie, at the principal points in the Ouse and New Nene; and it was proved that the low water of the same tide at the North Level Sluice was three inches below datum, or fifteen inches lower than at Free bridge; that the low water of the same tide at Marshland Sluice was thirteen inches above datum; that the same tide above Sutton bridge was four inches below datum, or sixteen inches lower than at Free bridge, and that the same tide below Sutton bridge was three feet six inches lower than at Free bridge. These water levels taken in dry weather, have, as I have already noticed, little to do with the capability for drainage, but the following fact is deserving of notice, that in the Nene Outfall, between the North Level Sluice and Sutton bridge, (two and a quarter miles long,) and in the Eau Brink, (two and three quarter miles long,) the summer low water fall on the surface of the water, was only one inch by one observation, and that by other observations it was found that the low water at Marshland Sluice was level with that at Lynn, and also that the low water at the North Level Sluice was level with that above Sutton bridge.

Mr. Walker's Plan.—I come now to state my own views of this important and difficult question.

My instructions are, to suggest the very best means of effectually improving the drainage of the Middle Level, having regard to navigation. And this I propose doing, by entirely separating navigation from drainage. Both useful in themselves, they have been long united, but have never agreed; and the attempt to reconcile them, and at the same time to keep them together, has been the stumbling-block and difficulty of all the schemes I have referred to or know, as well as the great cause of constant disputes, and of nothing useful having been done to relieve the country from the evils which it has suffered, and of which all have been sensible. It will be allowed that the object was worth a trial on my part; and having given it my best consideration, I do not see the difficulty of draining the whole of the Middle Level by means of a new straight drain of sufficient capacity, made so low as to be entirely under such of the present rivers and drains as are navigable; these rivers and drains being carried over and across the new drain in cast-iron aqueducts, for the purposes of navigation, and the supply of fresh water for the land and for cattle. That this work will be attended with expense is certain; that it may affect several of the present interests and local acts, and thus, and from its novelty, give rise at the first view of it to opposition, is not improbable, but the operation is not difficult. Mr. Burgess, to whom I communicated the plan, and in whose practical knowledge I have the greatest confidence, is, after his survey of the country, and examining the scheme, of the same opinion, and I feel confident that it is the most, perhaps I may say the only, effectual measure.

Termini.—The termini of the proposed drain do not, I think, admit of much doubt. The lower terminus or bottom is proposed to be at the upper end of the Eau Brink Cut above the present Marshland Sluice, the same point as was proposed by the late Mr. Rennie. The upper end is near Caldecot Farm, on the west side of Whittlesey Mere. The length between the two termini, measured in a perfectly straight line, is thirty-one miles.

Lines of Drain.—First Line.—Between the two termini, a number of lines have been surveyed and levelled. Of these, the most direct or shortest, passes through the very low land in Magdalen Fen, in Marshland,

crosses Well Creek a mile east of Outwell and Upwell, thence in a straight line to Popham's Eau, which it crosses a mile west of Three Holes bridge; then straight to half a mile north of the turnpike upon the road between March and Doddington; then to the Old Nene, a mile south of Flood's Ferry, whence the line is straight to its upper termination: the whole length in the line of the drain being thirty-three miles. This line passes very nearly through the middle of the Level: it is the straightest. Its principal disadvantage is the crossing, for three-quarters of a mile in length, the high land near March, which, as respects expense, would partly balance the saving in length. The passing through the low fens in Marshland cannot be a disadvantage, but otherwise, as may, I think, be proved to the satisfaction of the landowners.

Second Line.—The second line keeps near the foot of the high land adjoining the Ouse, in nearly a straight line to the Tongs Drain, which it falls into above the Tongs Sluice, and continues in the Tongs Drain up to Nordelph, where, after passing under Well Creek, it follows in the same straight line for eight miles to near Fodder Fen-house, when it curves to the west, and passes under the Sixteen-foot river, two miles from its south termination, and to half a mile north of Carter's bridge, and thence straight to Dauntry Farm, on the east bank of Whittlesey Mere, where it joins the line before described. This line has the advantage of using the Tongs Drain for three miles, and of passing through Low Fen for its whole length. The disadvantage is the greater length by five miles, the greater curvature, and the tending too much to the east for the convenient drainage of the whole Level.

Third Line.—A third line leaves the line last described at Nordelph, and proceeds in a straight line to join the line first described at the March turnpike-road, crossing in its way the Sixteen-foot river near the "Crown" public-house. This line is a mile shorter than the last, and four miles longer than the first described. It has the same disadvantages as the first line, in crossing the high land at March; it is more in the middle of the Level than the second line, but not so much as the first.

Mr. Walker's opinion of Lines.—It is not easy to calculate the value of opposition, the interests of parties and collateral circumstances; but, as an engineer, and having reference to the points in my department, so far as I am now aware of them, my decided opinion is in favour of the first described line.

Descriptions and dimensions of Sluice.—The width of the sluice into the Eau Brink, I propose being not less than fifty feet, in two or three openings; its sill laid six feet under datum level, or seven feet under the present low water at Free bridge, which, though only two feet under the Tongs sill, I consider sufficient for the present state of the river; but I propose the floor or apron to be so constructed that the sill may easily be lowered two or three feet, should any improvements below Lynn ever so lower the river as to make this alteration useful.

Outfall below Lynn.—That the outfall below the Eau Brink Cut may be lowered, is proved both by the Nene Outfall, which also empties into Lynn Deeps, and from Mr. Rendell's survey, made for the Port of Lynn, which states the fall from Lynn to low water in Lynn Deeps to be seven feet; also, from the fact that the tide rises for three hours in the Roads before any rise takes place at Free bridge.

Dimensions of Drain.—The bottom of the drain is intended to be one to two feet lower than the sluice sill, and to be level for its whole length, which will therefore be about fifteen feet under the average, and about eleven feet six inches under the lowest fen. Its width at its outlet to correspond with the sluice, and to be contracted gradually to its upper end, where I consider twenty feet bottom will be sufficient. The bottom of the iron aqueducts for the present navigations will thus be twelve feet above the bottom of the new drain. [A model of an aqueduct crossing the drain under it at right angles, which will sufficiently illustrate what is here proposed, will be submitted to the meeting shortly to be held at Chatteris.]

Catchwater Drain.—A catchwater drain at the foot of the high lands, will convey the high land waters into the present rivers, for the use of the land and for navigation. The height in the rivers may be regulated at pleasure by means of draw sluices communicating with the main drain. One of the present Upper Tongs draw sluices placed at the lower end, and the other near the head of the drain, will be sufficient. Having examined, with Mr. Laurance, the small extent of high land that drains into the Middle Level, I cannot but think that unnecessary importance has been attached to it, and that the provision made for it by the catchwater drains that gentleman proposes, is judicious and sufficient.

Whittlesey Mere.—The new drain, of the capacity and low level I have described, will render the drainage of Whittlesey and the other Meres practicable, without damage to the Level generally, and it is only by some such measure that the drainage of the Mere could, in my opinion, be made so; for, as things now are, I could never see how the Meres could be dispensed with as a reservoir in times of floods, when there is no outlet to the sea. When this is the case, at present, the fen water pumped up by the mills has an area of four thousand acres to spread over; yet, last winter, it was raised to the height of nearly four feet above the navigation level, which is as high as the wind-engines are made to lift. In many places it ran over the banks. By enclosing the Meres, the area would be reduced to one thousand acres, one-fourth of its present area. The result, if the Meres were inclosed, and the present drains continued as they are, is, I think, evident. I cannot give an opinion of the legal rights, or of the argument I have heard advanced, that as other Meres have been drained without hindrance, all may. Mr. Laurance complains of the foul state of some of the drains being one of the causes of the severe losses by the floods of last winter; and states, that after the low water at the Tongs Outfall had subsided four feet, the water was days and weeks before the effect was felt up the country. This arose, also, no doubt from the mills continuing to pour their water into the drains. The very foul state of the Sixteen-foot and Twenty-foot, and some of the other lodes, unquestionably contributed largely to the evil, and is, perhaps, to be accounted for by the notion, that while the final plan was unsettled, but expected not to remain so long, it would be impolitic to go to an expense that might be useless.

Comparison of Plans.—The plan of enlarging and deepening the present drains would, to be sure, much reduce the necessity for retaining the Meres as reservoirs; Mr. Laurance's plan of an outlet at Marshland would reduce it more; Mr. Rennie's plan of a great drain, still more; the entire separation of navigation from drainage which allows the drains to be sunk to the greatest depth, and to be emptied at every tide without injury to the navigation, most of all. The excellent effect of the New North Level works, in giving a natural drainage to seventy thousand acres, the lowest part of which, at fourteen miles from the outlet, is two to three feet lower than Whittlesey Mere, and is as low as any part of the Middle Level, is the best possible illustration of this opinion.

Natural Drainage.—But, supposing the plan I have here proposed to be the most effectual for the drainage of the Middle Level, having regard to navigation, which I believe it to be, will it also give a natural drainage to the whole of the Middle Level? This question may be considered either as a separate question, on its own merits, or in reference to the North Level and other similar cases, making due allowance for the differences.

Levels of Fens.—As to the first, the very low ground a mile south of Ramsey Mere, is seven feet, and the average level of that low district is eight feet above datum. On the north and west of Ramsey Mere the lowest part is about seven feet, and the average a little more than eight feet above datum. The lowest part of Whittlesey Mere is seven feet nine inches, and the average eight feet six inches above datum. The lowest part of the Washes around the Mere is eleven feet, and the average, which will include also Yaxley, Stilton, and the adjoining Fen, eleven feet six inches above datum. The lowest ground in Wood Walton, Connington, Sawtree, and Holme, upon the banks of Monk's Lode, Ravely Drain, and the New Dyke, is ten feet, and the average twelve feet above datum. Between Ramsey and Well Creek, the lowest land is seven feet three inches, and the average nine feet above datum. In Manea and Welney Levels, the lowest land is seven feet, and the average eight feet above datum. In Marshland, the lowest land is only five feet three inches, and the average of the various lines surveyed by me, six feet above datum. The low water of the heavy floods of last December, was four feet six inches above datum at Marshland Sluice; so that the lowest land in the Middle Level may be said to be two feet six inches, the average of Low Fen three feet six inches, and by far the greatest portion, perhaps two-thirds, of the whole, seven to eight feet above flood level.

Capability of Drainage.—To determine the capability of drainage, some allowance must be made for time and distance. I have already stated the incorrectness likely to arise from not separating flooded rivers from internal drains, in considering the question. If the North Level requires any such slope on the surface of the water as four inches per mile, it must arise from the bottom of the drain being made to have the same rise. But, notwithstanding this formation, I have shown that, as the land at fourteen miles distance has natural drainage, the fall in the surface of the water cannot be so much as two inches per mile; also, that at low water in the Nene Outfall, and the Eau Brink, the water at the upper end of each cut ebbs as low as at its outlet. I have stated that I propose the new drain for its whole length to be level. The bottoms of the present narrow and crooked rivers and drains, from the Upper Tongs, or Whittlesey, are level, still the water draws to the Tongs, badly, I allow, but this is more to be ascribed to their foulness, crookedness, and small size, than to any other cause. This, I think, is evident, that in the present state of the rivers more than I have proposed cannot be done;

and if the late Mr. Rennie was correct in stating that the drain he proposed would give "perfect drainage;" if Mr. Laurance's plan would, as he thinks, give a "natural drainage" to all the lands near his outfall; the plan I propose will be very much more effectual and extensive in giving natural drainage to the whole of the Level.

My own opinion, however, is, that there are some low places upon which, in high floods, water may for a short time stand too near the surface for perfect natural drainage, but that, with these exceptions, the natural drainage of the Middle Level would be accomplished by the measure with greater certainty than by any that has hitherto been proposed.

Improvements below Lynn.—Whenever, either by means of a cut across the marshes below Lynn, as proposed by the late Mr. Rennie, or by continuing and straightening the channel, as is doing in the Welland, the low water in the Eau Brink Cut shall be lowered, then the natural drainage of every part of the Middle Level may be considered complete. The improvements below Lynn would benefit that port, as well as improve the drainage of both the south and Middle Levels. Mr. Rennie's opinion of its importance is proved by his predicting "that after the Eau brink cut should be made, its beneficial results would be so much felt by the proprietors of land, the navigators, and the harbour of Lynn, that in a short time it would be the unanimous desire of all concerned to extend it further to seaward."

Proof by North Level.—Judging, again, from experience, the surest of all tests, and applying the facts I have stated respecting the North Level to the Middle Level, I should say that the natural drainage of even the lowest parts would be complete. During the floods of last winter, the water (says Mr. Laurance) was fourteen inches lower at the North Level Sluice than at Marshland Sluice; but I think this advantage over the Eau Brink, in a place so far distant as the Cross Guns, must be more than balanced by my placing the proposed sill five feet lower than the North Level sill, and by making the proposed Middle Level Drain level, in place of rising three or four inches per mile, as the North Level drain does. If the fact was, as I believe it to have been, that these low spots of the North Level did suffer in a degree last year, (though for the first time, perhaps), this will agree better with my notion of what is under the circumstances probable. Supposing, however, that the natural drainage would not be quite perfect for every part in high floods, even these excepted parts will, notwithstanding, be much benefitted. The flood water over the whole country will be kept six feet lower than it has been; there will be very much less water to pump, and less height to pump it, less damp and greater salubrity, with the positive certainty that the application of a small power to the very lowest part, will ensur against a recurrence of any of the evils which were suffered last winter.

The observation that alterations will be requisite in the present drains, to correspond with the new level, is correct; and if the greatest advantage is to be taken of the new cut, some new leading branch drains will be required to be made, and many of the present drains to be deepened and enlarged; but this is not the effect of my proposal of a distinct drainage; for, as respects lowering, and partly as respects new branches, though not to the same extent, it would be applicable to any plan of improving the present rivers and drains. Every piece within the Fen may communicate, directly or indirectly, with the proposed main drain. Where it is desirable to keep up the present main drain for navigation, the secondary drains will be deepened, and turned into the main drain in other cases. New branch drains for drainage, with a staunch at their communication with the main drain, will be required. Where the distance from the main drain is great, the length, and consequently the expense of these branch drains, will be considerable. I refer particularly to that for the Mepal and Sutton district, which is by far the greatest distance from the main drain.

Meres.—Whittlesey, and the other Meres near it, which are now of no value, will profit the most; the quantity I apprehend is altogether four to five thousand acres, the area within the Mere banks being two thousand five hundred acres. If the value of this description of land, and the importance of improved drainage, may be judged of from the expense and labour of inclosing Yaxley Fen, it must be very considerable. An Act was obtained for reclaiming six hundred acres of this fen, a twenty-five-horse steam-engine erected, the banks formed which last winter's floods have much injured; and, in addition to the Eau Brink, and other taxes, the land has been for the last seven or eight years taxed twenty shillings per acre per annum for expenses, and a tax (with some reduction, it is hoped, from the present) will continue for years to come.

Navigation and Drainage Levels.—As the internal rivers and main drains are used not only as thoroughfares for the general trade of the country, but for conveying the produce of the land (in many cases from the barn-door, without carting) to the market, or to Lynn Harbour, any improvement to the navigation is an improvement to the land, and consequently adds to its value. Now navigation prefers an uniform level of water at all seasons; land requires it to be kept down to the lowest level in wet seasons. Here, on principle, the two do not agree: and when, as in the present case, the established or lowest navigation level is above the average of all the land, and some feet above a portion of it, the principle becomes powerfully illustrated. The opposite interests are to be reconciled only by separation, and this is done effectually by both being placed in the best condition, the water in the main drain kept at the lowest possible level, if desired; the water in the side drains at such level as may be the best for the particular land, and the navigation again kept above both, at an uniform level.

Navigation and Fresh Water.—The internal rivers, for the purposes of navigation, and the supply of fresh water, will, I think, be materially benefitted by the certainty of being able to maintain nearly the same level of water at all times, and of a quality superior to the present, which is partly the Fen water. There seems no reason to doubt that the present sources of supply of fresh water from Standground, the high lands, the Hundred-foot at Mepal, and Salter's Lode, will be ample. Navigation may therefore be expected to contribute, in some proportion, to reimburse the expense of the new works. I have not calculated upon the navigation level being raised so as to give a greater depth of water, although this would be an improvement, to which, on the part of drainage, there could be no objection.

Expense.—As to the expense, compared with the other schemes, it is to be noticed, that a branch of the cost, I mean the navigation, is left untouched, and therefore incurs no expense, which would not be the case according to any other plan; and that thus great expense, to suit the new levels, as well as great trouble and opposition, will be avoided. The future repairing and supporting the river banks would be attended with only little expense. The comparative non-interference with the houses, mills, bridges, and other erections by the side of the old rivers and in the towns, which would have to be taken down or interfered with by the other plans, will be another saving of expense. In the line I propose, but few mills or buildings need be removed; the present mills upon the banks of the rivers may stand undisturbed until any doubt of their further assistance not being wanted be removed by experience.

Crossing Fields.—The evil by bisecting fields to a greater extent than the other plans (Mr. Rennie's excepted), is unavoidable, if the plan proposed by me be adopted; the same temporary inconvenience takes place in the laying out of new turnpike roads and railroads, which cannot, I presume, be considered so important for the occupier of land as good drainage is for this country.

By balancing these considerations, perhaps a more correct average even as to cost is to be obtained, than by referring to estimates, particularly in matters of compensation, where the demand is arbitrary, and the amount of damage uncertain. Without particularising, I must say that in my opinion some of the estimates I have heard named would be found very far short of the cost. Let it be remembered, also, that, as respects the policy of improving the present rivers and drains, you are furnished with the high authority of the late Mr. Rennie, who, in 1809, states, "that the Old Nene is very crooked; that the expense of making it of sufficient capacity to receive the water which would drain through it, will be very great, and that it would therefore be better to make a new cut to Whittlesey Mere." If this were sound advice thirty-two years since, it must be more so now, when the improved drainage of the district brings down the water much more rapidly.

Future Saving.—The saving in the future expense of the present works of drainage is to be considered. The hundred windmills, taken at £80 per annum, give £8000 per annum; the cost of each renewal is from £600 to £1000. There are three steam-engines in the Level; a fourth is building. Steam is a preferable power to wind; but if there were steam power to pump up all of the Fen water, there is not river-space or reservoir enough to receive it. It would, even with Whittlesey Mere, flow back over the banks into the Fen, and if Whittlesey Mere were embanked, the case would be very much stronger. If, again, the rivers be enlarged according to any of the other plans, a large proportion of the expense, to say the least, is incurred, and, as I think, comparatively less good done, and the seeds left for future disputes between navigation and drainage. My opinion therefore is, that even as respects cost, the most efficient plan would be found at the end the most advisable, just as building a new house is generally a more satisfactory, as well as in the end a cheaper plan than altering and enlarging an old one.

Estimate.—Borings have been made along the proposed line by Mr. Herbert, one of my assistants, to ascertain the nature of the strata; an account of the probable number of bridges and other works has also been taken; from these, and the application of my experience

in similar works, I have estimated the expense of the main drain at £360,000. This includes bridges, aqueducts, and a tunnel under the bank, with a staunch at one mile distance on each side for the drainage from the lands. There has not been time for detailed drawings of the various works, which would have been desirable for a particular estimate. The above amount, spread equally over the whole area of the taxable land in the Middle Level, and the Meres not yet taxed (exclusive of any part of Marshland), is on the average £2 10*s.* per acre. If, however, the cost makes the execution of the whole plan at once difficult or impracticable, it may be done by degrees or stages, each being useful as done. Thus, the new outlet sluice and cut across Marshland, and terminating at Popham's Eau, would give very great relief to the whole level; but I trust there will be no occasion for this tedious process.

Ouse below Denver and South Level.—The last instruction to me is, that I direct my attention to the state of the river Ouse below Denver Sluice, with a view to consider "whether any and what improvement can be made in that river, to make it more effective for the drainage of the Middle and South Levels."

So much of my time and attention have been given to the matters already reported, that the South Level may not have had so much consideration as you wished it to have. If the plan I have recommended be adopted, the Middle Level, as respects drainage, will be independent of the Ouse above Marshland; and as the above instructions do not, as respects the South Level, appear to contemplate my examining the interior of that district, my information of its state of drainage is not such as to justify my recommending any large measure on account of it. It is probable that here also the drainage would be improved by keeping the internal drainage clear of the river for a considerable way below Denver Sluice. As respects the Sluice itself, the new work appears perfect, and the sluice-keeper states that it does not form the slightest obstruction during floods; but the other checks to drainage, arising partly from artificial obstructions, may be judged of from the fact, that on the 5th of December last the low water at Denver stood three feet ten inches higher than at Tongs, ten feet higher than at Marshland Sluice, (the distance being ten miles,) and eleven feet seven inches higher than at Lynn.

Suggested Improvements.—The above falls may be reduced, for there are obstructions, particularly the shoals between Denver and Downham; and Magdalen Bend may, as has often been recommended, be cut off. By conveying the drainage water below Magdalen before it enters the river, the result would be very much more effectual. George Stephens, the Denver sluice keeper, told me he has seen in floods the water in St. John's Eau close to the sluice, three feet lower than in the river there. Yet this flooded river (the Ouse) is the great drain of the South Level.

St. John's Eau.—The history of St. John's Eau is confused. At present it is in a miserable state, almost closed up. A new outlet sluice was made fourteen years since, about half a mile below Denver, with a new drain parallel to the river. I have not discovered the reason of a new sluice being made to divert St. John's Eau into the river here, rather than letting it go to Stow Bridge, its proper outlet. That the principle was bad, and that the water still prefers its old course, notwithstanding the neglected state of the Eau, is proved by this, that at the time Stephens noticed the three feet difference above named, the new doors were shut, and that the Old Stow Fall doors open, when the new ones do not open at all. Surely, then, St. John's Eau should be attended to; and if the drain can be extended to the general drainage of the Level, it may be desirable to consider as to its being carried down so as not to join the river, after passing the Magdalen Bend.

Effect upon Drainage and Navigation of Ouse.—The great measure I have proposed for the drainage of the Middle Level, will take down to Marshland a portion of the water that now enters at the Tongs. The tendency of this will be injurious to navigation, but it will not be so to the drainage of the South Level, or to any other drainage, but rather the reverse, as it is in flood time that the defect is felt, when any water poured into the upper part of the river tends to raise the surface of the river, and thereby to injure the drainage, while the navigation derives the benefit of the increased scour lowering the bottom of the river at all seasons.

If the navigation can call upon the drainage to make good any real or supposed evil, it might be well to consider if the drainage interests should keep the river in as good a state as it now is, without increase of expense to navigation. Navigation could not then complain, and all the drainage of the South Level would be improved, by there being a less quantity of water to pass through the same channel.

The principle which I have kept in view in discussing the subject of the Middle Level drainage, may perhaps be applicable to the South Level also. If this is so, the importance of the subject is increased, and the length to which my enquiry and this Report have been extended, in my endeavour to state the best possible mode of drainage for the Middle Level, will be the more readily accounted for and excused.

I have now only to acknowledge the information and assistance given to me by Mr. Wells and Mr. Archer, and the readiness with which I have been attended by Mr. Joseph and Mr. Harry Little, and Mr. Owen, from whom I have received much local information, and many useful suggestions; and I am sure that Mr. Wing, to whom I applied, would have enabled me to have given more precise and probably more correct information as to the New Nene and the North Level drainage, if he had not thought that circumstances which had occurred previous to my being called in, and with which I am unacquainted, prevented his doing so.

Great George Street, Westminster,
28th August, 1842. JAMES WALKER.

LETTER OF SIR JOHN RENNIE, F. R. S., TO HIS GRACE THE DUKE OF BEDFORD, GOVERNOR OF THE BEDFORD LEVEL CORPORATION.

London, 26th October, 1842.

"MY LORD DUKE,

"As Governor of the Bedford Level Corporation, and as a descendant of the great Earl of Bedford, to whose perseverance and patriotism the original drainage of the Fens is justly ascribed, your Grace will, I hope, permit me to address to you some remarks upon the Report of Mr. Walker, of the 28th of August last, respecting the improvement of the drainage of the Middle Level. I trust that in doing this I shall not be considered as coming forward unnecessarily, or as being actuated by the mere desire to comment upon Mr. Walker's Report, or in any way to interfere with the undoubted right of the Proprietors of the Middle Level to adopt whatever measures may appear to themselves to be most conducive to their own interests; but as Mr. Walker has felt himself called upon to criticise the Plan of my father of 1810 for the general drainage of the Middle Level, as well as mine for the drainage of a portion of it, dated 1836 and 1840, and has made some deductions from the working of the Nene Outfall, in which I cannot acquiesce, and has proposed a plan of his own at variance (as it appears to me) with some of the general principles of drainage, as laid down heretofore, and acted upon with invariable success, by many of the most distinguished engineers; I feel it a duty which I owe to the memory of my father, to myself, to your Grace, to the Bedford Level Corporation, and to the country generally (who applied for our opinions on this important subject), to explain the principles upon which those opinions have been given, and to prove that they are correct, and would, if acted upon, still be found most conducive to the general welfare of the country.

"I will begin by observing, that all rivers passing through a flat alluvial district like the Fens, have their mouths or points of junction with the sea generally encumbered with shoals or bars, and their channels circuitous. The former circumstance arises from the deposition of alluvial matter, partly brought in by the tides from the adjacent coasts, and partly from the interior country, and held in suspension by the current only so long as the current retains sufficient velocity to carry it forward; when, however, the velocity is diminished (which is generally the case as it approaches the sea, from the reduced inclination of the bed, and the opposition offered by the wind and waves) the gravity of the alluvial matter prevails, and it is deposited in form and dimensions according to the obstacles offered to its progress. Hence, if we examine the channel of a river from its source, we shall find the materials transported by the current diminished from large blocks, to gravel, sand, and mud, as it approaches the sea; and as regards the latter circumstance, namely the circuitous channel, this arises in a measure from the efforts of the internal currents to increase the channel or receptacle for water, in order to provide the means of overcoming the superior antagonist forces of the winds, waves, and tides of the ocean, which, however, are in general too powerful; so that the free discharge of the waters from the interior is prevented, and the adjacent low lands become flooded and unfit for cultivation.

"As the natural tendency of the outfalls or mouths of rivers and channels is to decay, the first object of engineers has been to remedy these defects, and, by regulating the natural channels, to render them more effective for the discharge of their waters. The next, to conduct the surface waters from the adjacent lands by means of artificial channels or canals, in as direct courses as practicable, in order to economise the natural fall or inclination, and to enable them to be discharged into the main rivers at the most convenient points; it being justly conceived, that the more the natural courses of the rivers can be used the better, as saving the needless expense of making and maintaining two channels, and that the greater the quantity of water that can be made to pass

through one channel, the greater will be the certainty of keeping that one open.

"In addition to these two grand and fundamental principles of drainage, my father, who adopted them generally both in theory and practice, introduced a third, almost equal in importance to either of the other two, namely, the *catchwater drain*; the intention of which was to intercept all the water coming from the highland districts bordering upon the Fens, and to discharge it into the natural rivers above the level of the Fens; so that it only remained to carry off the water, which actually fell upon the low lands, an object in many cases of comparatively easy accomplishment: whereas, when both are mixed together, the high land water coming from a higher level, and necessarily with a greater velocity, over-rides that from the low lands, and forces its way first to the outfall, leaving the other to accumulate upon the Fens.

"This principle he carried into effect with complete success in the drainage of the East, West, and Wildmore Fens, a district comprising about 75,000 acres, bordering upon the river Witham to the north of Boston: here also he endeavoured to employ the channel of the Witham, as far as practicable, as a receptacle for the drainage waters, but as this, at the time, was much encumbered with shoals, he proposed, as an indispensible condition, that it should be improved in the first instance. Circumstances, however, prevented this from being done at that time; he nevertheless made the Maud Foster Drain (which was chiefly for the discharge of the high land waters) to enter the Witham by a sluice immediately below the town of Boston, whilst the main drain for the discharge of the low land waters was made to enter the Witham at Hobhole, about three miles below the town; but clearly foreseeing, that unless the outfall of the Witham was improved in the first instance, it would be impracticable to discharge the high land water by the Maud Foster drain, he provided a communication between it and the lower or Hobhole Drain; so that the whole of the water might, if necessary, pass that way. What he foresaw, actually came to pass; the outfall of the Witham not being improved, gradually became worse, the entrance to Maud Foster drain was almost filled up, and nearly the whole of the water was discharged for several years by Hobhole drain alone, until the year 1827, when the outfall of the Witham had become so bad, that the navigation to Boston was in a great measure lost. The Corporation of Boston then determined (at my recommendation) to carry into effect part of the plan of the late Mr. Rennie of 1800 (previous to making the East, West, and Wildmore Fen drainage): this was done by commencing at the lower end, and was completed in 1829: a surprising effect was produced almost immediately; the navigation to Boston was restored, the shoals in front of the Maud Foster drain were removed, and it has ever since continued to discharge the high land water from the Fens with the greatest effect.

"Thus the three grand and fundamental principles of drainage may be said to be, *improvement of the outfalls and channels of the rivers, judiciously-constructed interior drains for the low-land waters, and catchwater drains for the high-land waters.*

"The precise fall or inclination of the current requisite for the proper discharge of a given quantity of water in a given time from a fen district, has been a matter of much discussion and experiment; the generally received doctrine, however, is, that rivers will discharge the waters with sufficient rapidity to keep the Fens dry, having a fall of four or five inches per mile, if their outfalls be kept open, and their channels properly regulated; and that the bed of an artificial canal or drain should be laid with an inclination corresponding, in ordinary circumstances, to that of its surface. This principle is distinctly laid down and adopted in their respective Reports on the North Level Drainage, by Smeaton, Brindley, Golborne, Yeoman, Watti, Elstobb, Edwards, Telford, the late Mr. Rennie and others; and Mr. Telford concluded that four inches per mile was sufficient for the Nene outfall, and the actual result comes extremely near to it; indeed, below Sutton bridge, according to the recent levels of Mr. Fulton, it is little more than three inches per mile, and if the fall at the bridge was removed, and the channel improved upwards, which might readily be effected, a proportional inclination might be established upwards.

"The reason why the fall of the surface current of the Ouse, above the Eau Brink Cut, is eleven inches per mile, as stated by Mr. Walker, consists in the obstructions to the discharge of the waters, both above and below that point, particularly at St. German's, Magdalen, Stow and Downham Bridges, also at the bend in the river above Magdalen bridge; so that they are compelled to rise to an unnatural head before they can get to sea: if these obstructions, however, were removed, and the channel properly regulated, the fall or inclination of the current above the Eau Brink cut, together with that of the cut itself, would not, probably, exceed five or six inches per mile, although at present the latter is stated by Mr. Walker at five inches and 8-tenths per mile. Why Mr. Walker should say (see page 16) that eight inches per mile would be too little for the Nene, when improved, when that portion (which is finished) is little more than three inches per mile, I am at a loss to conceive; the more so, as the Nene being in the centre of the Great Valley of the Wash, is decidedly nearer to the open sea, and, with a more direct course, has less obstructions to the discharge of its waters.

"Having thus endeavoured to point out what have been generally the received doctrines, as regards drainage, by the most distinguished engineers, I shall now proceed to the more immediate object of this letter.

"Your Grace is, I believe, aware that in the year 1810, my father, at the request of the Bedford Level corporation, proposed a plan for the general drainage of the Middle and South Levels, which consisted in the improvement of the outfall by the Eau Brink cut, as an indispensible preliminary to any improvement of the interior drainage, and catchwater drains, to intercept the water from the surrounding high lands; and upon this last provision he laid great stress, both as a protection against winter floods, and as the means of affording a supply of fresh water in summer, which is an object of the utmost importance. In addition to the above two grand measures, he proposed that the Ouse should be improved, by taking off the bend at Magdalen, by removing the old defective bridges, and by enlarging and deepening the channel upwards to Earith; and furnished a very elaborate plan for collecting the waters from the various districts of the Middle Level, making use (whenever practicable) of the existing drains and water courses, (in order to save expense, and to prevent, as much as possible, any derangement of properties and existing communications) and discharging them by a main drain from Popham's Eau to the head of the Eau Brink cut, running parallel to the Ouse, by which course, all the great, if not insuperable difficulties and objections to passing through marsh land, as proposed by Mr. Walker, would have been avoided. All these drains would have served the purpose of inland navigation, in the same manner as the drains constructed by him in the East, West, and Wildmore Fens, and which have never yet been surpassed in efficiency and convenience. The estimate of that portion of the plan for the interior drainage of the Middle Level, only amounted to the sum of £252,000. Besides the works above mentioned, his plan included catchwater drains from Standground Sluice to Earith, deepening and enlarging Popham's Eau, the old Bedford, Thurlow's drain, or the Sixteen-feet, Vermuyden's drain, or the Forty-feet, cleansing part of the Old Nene, and a new drain to Whittlesey Mere, with the alternative of deepening and enlarging Bevil's Leam and the Old Nene, through its whole course—being £108,000 less than Mr. Walker's plan; and from the well known accuracy of the estimates of the late Mr. Rennie, there is very little doubt but that the works in question would have been executed for that sum.

"He also stated that several other works would be required, before the plan could be rendered complete; and amongst others, he pointed out the importance and advantage of extending the Eau Brink Cut below Lynn.

"Such was the general outline of his plan; and could he have lived to see it carried into effect, and to experience the results of the operation of the Eau Brink Cut, (if he had not succeeded in prevailing upon the country to extend that work below Lynn) he would, no doubt, have proposed an efficient system of steam drainage, (with which, though then in its infancy, he was well acquainted, having constructed one engine for the Bottisham Fens in 1821, and proposed another for part of the North Level, as well as Deeping Fens and other places) in order to relieve those portions of the Middle Level, which could not be drained effectually by a natural drainage into the Ouse; and the subsidence of the soil, occasioned by the improved drainage compared to what it was in 1810, when Mr. Rennie made his Report, now renders it necessary to improve the outfall still further, in order to insure the benefits of complete natural drainage to the whole Level, if it is to be effected by the Ouse, and this Mr. Walker seems to admit.

"With regard to the plan (and my Reports on it) for the improvement of the river Nene, and the drainage of Whittlesey Mere and the adjacent parts of the Middle Level, by the Nene at Guyhirn.—This suggestion did not originate with me, neither did there at that time exist any plan for the improvement of the drainage of the Middle Level, (except my father's, by the Ouse) or any desire, as I understood, to admit the waters of Whittlesey Mere and the adjacent districts to pass that way; but it was submitted to me by a public meeting held at Peterborough in the year 1835.

In pursuance of the instructions then given to me, I examined the levels of the above district, and having ascertained that, generally, a fall of four inches per mile, as recommended both by the late Mr. Rennie and Mr. Telford, could be obtained to what might be made the ordinary low-water mark of the Nene at Guyhirn, I felt no difficulty in recommending the plan; and with regard to the very lowest parts of the district, where the same fall could not always be depended upon (and these portions scarcely amounted to a few hundred acres, and bore no proportion to the whole,) I proposed to remedy this deficiency by means of the great size and straightness of the new drains, and by the sluice at Guy-

hirn, which was proposed to be not less than forty-five feet wide for 50,000 acres; whereas the new North Level Sluice (which so successfully drains about 70,000 acres) is only thirty-six feet wide; and in 1840 I improved the plan, by proposing to remove the obstructions at Sutton bridge, and to carry the Nene by a more direct and shorter course to sea, by which means an additional fall of three feet would be gained: so that, notwithstanding the objections urged against the plan by Mr. Walker and others, of discharging part of the waters of the Middle Level so high up the Nene as Guyhirn, I have no doubt whatever but that it might be successfully completed, without resorting to engines in any case, or, if in any case, the instances would be so few, and the surface to be drained by them so small, as not to detract from its merits as a system of natural drainage. Indeed, Mr. Walker's levels and opinions as to the requisite fall for interior drains, as contained in his Report, corroborate this opinion completely, if further proof be wanted; for by draining this district into the Nene, there would be a fall of two to three inches per mile during floods from the lowest parts, and more from the greater portion of it, which would be obtained at a cost of £143,836, or nearly £2 18*s.* per acre; whereas, according to Mr. Walker's plan by the Ouse, there would be scarcely a fall of one inch per mile, and obtained at a cost of about double, because the lands which lay most contiguous to the Ouse are much higher, and ought not to be assessed at one-half the rate of those at Whittlesey Mere and the adjoining districts; and, notwithstanding it may be considered that this plan might be superseded by a more general plan, by the Ouse, I see no reason to change any opinion that I have given; and I have no hesitation in still maintaining, that my plan for draining a portion of the Middle Level by Guyhirn, combined with the catchwater drain, and the improvement of the Nene, would be most effectual, and be a great relief to a large portion of the Middle Level, situated as it is, several miles nearer to the Nene, which at present is the best outfall to the sea.

"Mr. Walker appears to object to this plan, chiefly because of the drain being made to discharge its water so high up the Nene as Guyhirn, and to admit that his objections would be removed, if the drain was made to enter the Nene lower down. To this alteration I, as an engineer, can see no objection; but I cannot admit of the necessity of doing so, as it would be attended with great additional expense, without any commensurate advantage.

"With regard to Mr. Walker's plan, and I should be sorry not to explain it correctly, although the want of plans and sections renders it rather difficult, I cannot subscribe to his expression of its resemblance to that of the late Mr. Rennie; for, with the exception of his main drain, beginning at Whittlesea Mere, and entering the Ouse at the head of the Eau Brink Cut, it differs in almost every respect: he pays no regard to the improvement of the tidal channels, or to the extension of the Eau Brink Cut below Lynn; he has no catchwater drain; his scheme is totally distinct from, and unconnected with, the present interior drains and water-courses, and in no respects accommodates itself to the present district boundaries or communications; and, with all these omissions, the cost of his plan exceeds that of the superior and more comprehensive one of the late Mr. Rennie, by the sum of £180,000. Thus it appears to be defective in many of those great principles which the late Mr. Rennie, as well as Kinderley, Armstrong, Smeaton, Brindley, Mylne, Telford, and the other great authorities who preceded him, considered absolutely essential to works for the combined purposes of navigation and drainage. Mr. Walker has only provided one sluice of 50 feet water-way to discharge the water from the whole of the Middle Level, amounting to 144,000 acres, besides the high land water (coming from probably 45,000 more); whereas the plan of the late Mr. Rennie, in addition to a sluice of similar dimensions, had two sluices of 16 feet water-way each for the catch-water drains, which, together, amounted to not much less than double that of Mr. Walker's proposed sluice. In my plan for draining only part of the Middle Level by the Nene, with much greater fall than Mr. Walker's main drain, I have provided a sluice of 45 feet water-way for the drainage of only 50,000 acres, or one-fourth of the quantity proposed to be drained by Mr. Walker's sluice, besides two sluices of 16 feet each for the discharge of the highland waters from the catch-water drain. His main drain, moreover, by being laid with an uniform level bottom throughout its whole length, would be attended with great additional expense in the first instance, and very great difficulty and cost in the subsequent keeping open and maintenance; and since it is not intended to be used for navigation, the great depth at the upper end being from 16 to 18 feet below surface of land, would, if practicable, be useless; whilst at the lower end next the Ouse, there would be a head of 7 feet upon the outfall-sill even in summer; and again (see page 26) he says, that from the surface of the lowest lands, there would only be a fall of 2 feet 6 inches, and 3 feet 6 inches from one-third of the whole level, amounting to 48,000 acres, to the low water surface during floods at his proposed new sluice at the Ouse. Now, allowing that the water should be kept 18 inches below surface, and taking the distance from the centre of the low district at about 25 miles, he would have only 24 inches fall, or scarcely 1 inch per mile, without the relief of the catch-water drains. This, according to Mr. Walker's own showing, is manifestly insufficient for a natural drainage of those districts, and must necessarily require the use of lifting power so extensively as to derange any calculation as to the quantity of land which could be drained without artificial means; or of the inclination of the current, and its power of discharge; or of the influence of winds; or of the effects which such an immense body of water (from such an extensive district, with different velocities, according to their respective heads and distances) might have on the adjacent low lands through which the drain would pass, particularly on the porous soil of Marshland, penned up as the water in the drain would be during the closing of the sluice-doors by the tide; neither does it appear clearly how the supply of fresh water is to be continued during summer to the district of Whittlesea Mere, and its vicinity, either for stock or navigation; an advantage which, to a certain extent, is now enjoyed, and would be guaranteed in a superior manner by Mr. Rennie's plan, inasmuch as Mr. Walker's main drain being below the others might perhaps abstract the fresh water from them, unless the drain be only used to carry off the floods, in which case, with no current through it during an entire summer, it would be filled up with silt or weeds, so as to become ineffectual for its purposes when wanted.

"Again, by collecting the whole of the drainage water, low land as well as high land, and discharging it into the Ouse at the upper end of the Eau Brink Cut, the channel of the river between it and Earith would be deprived, for a length of above thirty miles, of a very considerable quantity of water, which now serves as a scouring power, and tends materially to keep it open, not only for the benefit of the Middle Level, but for that of the South Level also; the loss of which would be prejudicial to the channel, as well as to Lynn Harbour, and would render it necessary for the proprietors of the South Level to make a new outfall near the head of the Eau Brink Cut, to preserve their drainage; whereas the late Mr. Rennie, by providing for the improvement of the Ouse up to Earith, and discharging the upland water there, would not only have preserved the channel, but, by enabling the floods to pass off more readily, would have prevented their accumulating, as at present, to the great danger of the banks and of the adjacent country; and by lowering the level of the low water-line, as well as the inclination of the surface current, he would have enabled the present drains to discharge their water more easily. It is also very questionable whether a drain of such a length as that proposed by Mr. Walker, would not be more obstructed by ice than the open channel of the river, and thus, on that account also, when most wanted be least effective in its operation. For the reasons above given, and more which might be adduced if necessary, I am clearly of opinion (with all due deference to Mr. Walker) that the plan proposed by him for the drainage of the Middle Level is far inferior to that of Mr. Rennie, and is by no means well calculated to effect that desirable object, and, if completed, would be very far from being attended with advantages equivalent to the cost.

"Supposing such to be the fact (and I have no doubt of it), it may naturally be asked, what is the most desirable plan to be adopted? To answer this question, we may turn again to Mr. Walker's Report (page 18), where he states that he found that there was a difference of 3 feet 6 inches, during the months of May and June last, in the levels of the low water line at the lower side of the Free Bridge at Lynn and Sutton Bridge on the Nene, that is, the level being so much in favour of the Nene; this was during the summer, but in floods the difference is much more considerable. He also tells us that Mr. Rendel found a difference of 7 feet between the low-water line at sea and Lynn harbour; now, if the channel of the Ouse was improved below Lynn, the distance to the sea ought not to exceed six or seven miles, and the fall at low water would be reduced to about 3 or 4 inches per mile, or 24 inches for the whole distance, thus giving a clear gain of five or six feet in the fall between Lynn Harbour and the sea, which would be nearly double the fall which Mr. Walker states (in page 26) that he has for the drainage of one-third of the whole Middle Level, and that portion, the drainage of which is most defective. Again (in page 16), Mr. Walker states that the present fall of the current above the Eau Brink Cut is 11 inches per mile during floods, at low-water; but if the bend at Magdalen was to be taken off, the old bridges removed, and the channel improved, there is no reason why the inclination of the current should not be reduced to about five or six inches per mile,—this would give a gain of from three feet to three feet six inches between the Eau Brink and Denver Sluice. If such be the facts, and there is no reason to doubt them, the remedy is evident: improve the outfall below Lynn, cut off the bend at Magdalen, and improve the channel between the Eau Brink Cut and Denver Sluice, or higher if necessary; these works alone, which could be effected at comparatively little or no tax upon the country, would give greater relief than Mr. Walker's drain, at the expense of £360,000, besides the cost of its ramifications, which would amount to a very serious additional sum; and if any further work should be required, complete the catch-water

drain, as recommended by the late Mr. Rennie, between the Nene at Standground Sluice, and the Ouse at Earith. This would effectually protect the low Fen district from floods, from the high land waters, and, at the same time, afford abundant supply of fresh water during summer.

"By means of the above works, all the present interior drains and rivers would be brought into effectual operation, and be enabled to discharge their waters much more freely into the Ouse than at present, in consequence of the obstructed state of the outfall; if any improvement in them should be required, which I apprehend would be comparatively trifling, their exact extent, locality, and dimensions, could be ascertained with a degree of certainty and economy at present impossible, and the decision as to Mr. Rennie's cut from Popham's Eau to the head of the Eau Brink Cut, could then be made; at all events, the bend at Magdalen could be taken off, the Ouse improved between Denver Sluice and the Eau Brink Cut, and the bridges removed, and the internal drains might be deepened and enlarged, where requisite, and the navigation gauges, which are now so injuriously felt, might be lowered in a corresponding degree. The harbour of Lynn, also, from not being deprived of any of its backwater or scouring power, but rather having it increased, would be greatly improved; and the South Level, for the drainage of which the Ouse is also the receptacle, would participate in the general benefit; indeed, Mr. Walker himself entirely approves of extending the outfall of the Ouse below Lynn, and acknowledges the benefits which would result (see page 27), and I am only surprised that he does not recommend it as a preliminary measure.

"Let, therefore, the principles of Mr. Rennie's Report of 1810 be adopted, with such modifications as time and circumstances may have rendered necessary, and I have no doubt of a successful result.

"From what has been above stated, I trust that I have established to your Grace's satisfaction, the following points:—First. That the plan of the late Mr. Rennie of 1810, is greatly superior and more economical than that of Mr. Walker, and if carried out to the full extent of his designs, would have completely answered the object intended.

"Secondly. That the plan recommended by me for the drainage of a portion of the Middle Level by the Nene, is not only perfectly practicable, but would effect that object completely and better, and at much less cost than Mr. Walker's plan, and be a great relief to the Middle Level.

"Thirdly. That Mr. Walker's plan for draining the Middle Level would not effect that object without great additional measures beyond those which he had proposed, and would be attended with a most severe and unnecessary tax upon the Middle Level.

"Fourthly. That the drainage of the Middle Level by the Ouse may be accomplished in a far more effective manner, and at much less cost, by improving the outfall in the first instance, and adapting the interior works to it, or, if necessary, carrying on both together.

"I now beg leave to conclude, and I sincerely trust that the above remarks (which I shall be much obliged if your Grace will lay before the Board of the Bedford Level Corporation at their next meeting) will not be considered as having been made for the purpose of criticising Mr. Walker's Report, with whom I am very sorry that I am obliged to differ upon this occasion, but I felt that my silence upon such an important occasion might either be construed as giving my sanction to opinions of which I do not approve, or as an admission that those of my father and myself, which we have already given upon this subject, were erroneous and incapable of being maintained. I therefore felt it my imperative duty to explain fully why I still consider those opinions correct, and to endeavour to revive in the country those great and fundamental principles of drainage and navigation upon which the safety and prosperity of the Fens entirely depend, and without which, all interior works, however designed, are in reality of insignificant value.

I have the honour to be,
My Lord Duke,
Your Grace's most humble servant,
JOHN RENNIE.

THE TEMPLE OF VESTA, TIVOLI.

FROM THE ITALIAN OF SEBASTIANI.

THE much celebrated Tiburtine Temple of Vesta, erroneously called of the Sibyl, which is to antiquaries the principal object of a journey to Tivoli, deserved the first place in my letters, as it was the first to present itself to my view and to demand my admiration. But since it was necessary for me to make some laborious examinations, in order to recognize every member, and also to have recourse to measurements, the better to determine its proportions, I waited for a time when I should be quite at ease, wishing to give you, as accurately as possible, a description both architectural and antiquarian.

This most important monument, one of the finest remains of the ancient temples still existing in the vicinity of Rome, whether you consider its construction or its architecture, is situated in a most delightful spot on the confines of the city towards the east, on the edge of the rock which overhangs the abyss, where in ancient times the Anio precipitated itself. At first the place was called *Siculetum* or *Sicelion*, as mentioned by Dionysius Halicarnassus; then the *Arx Tiburtina*, very strong by nature, a name which it still preserves, being sometimes called *Castro-vetere*, and sometimes *Cittadella*. And as the rock did not present a sufficient area before the entrance of the temple, a strong construction of walls and arches was formed, which, as I before stated, is partly fallen. The temple is spherical, and of the class called peripteral, composed of a cell and peristyle, with eighteen columns, of which only ten are in existence, seven isolated, and three built up for three parts into a modern wall. Its order is generally considered Corinthian, but I think it ought rather to be called Composite, for in the proportions and forms of the several parts the architect did not follow the rules generally adopted in that order, but, on the contrary, indulged his caprice and genius, so that the variations are remarkable, but they are also commendable. The columns are 9.05 diameters high (Eng. 23ft. 9in.), with an attic base, but without the plinth, which was probably omitted that the passage through the portico might be larger and more easy. The flutes of the columns are twenty in number, and descend perpendicularly from the top to the bottom, and leaving between the one and the other a very perceptible space. In the shaft of the columns there is to be observed both the diminution in height, which, instead of being the seventh part of the lower diameter, according to the precept of Vitruvius, is almost the ninth part, and the swelling in the middle, called by the Greeks entasi, which is very visible, and is executed with so much grace that it renders the contour exceedingly pleasant to the eye. The columns are of travertino, the stone of the country, in many pieces, covered with stucco or very strong cement, as is also the external work of the temple, and they fall outward the fourteenth part of the diameter, without the eye detecting it. Such a circumstance makes one believe, that when these columns were erected, they might have been placed on ground a little inclined outward, as in fact is the case with the floor of the peristyle for the purpose of giving an easy course to the rain water. Perhaps this projection may have been occasioned by the removal of the upper part of the temple, the ruin of which may have expanded the circumference. The capital is not quite so high as the diameter of the column, and is one of the lowest of the examples I have seen of this order, and rather heavy for the size of the abacus, which is larger than that commended by Vitruvius, but novel in its workmanship and style. Two rows of leaves, eight in each row, of a peculiar form, carved with incredible skill, adorn its base (*callathum*); they more resemble the oak than the olive, though they have been by some one compared to the latter. From the second row of leaves, without caulicoli, spring four large double volutes, with a simple listello coming out, and sustain the angles of the abacus, turning as usual with two convolutions under it. The small volutes, called by Vitruvius *pelices*, are of a singular form, brought forward in the middle, resembling the horn of a goat, and turned with great elegance and beauty. An open isolated leaf rises in the middle of these, which, inclining at its extremity, terminates under the flower, as if to fill up the space between the greater and less volutes, while other small leaves cover their listelli, and unite and curl under the angles of the abacus, according to the usual rules for the Corinthian and Composite abaci.

The flower consists of six leaves like the lily, with a seed in the middle, and at a distance from the abacus, with which it is connected by two pyramidal stems turned over two little leaves, plain, and much raised, which together form a good combination. The leaves at their rising are tied with a band, which cannot be seen at a certain distance, in consequence of the projection of the collarino.

The order is crowned by a light entablature, two eleventh parts of the height of the column, divided as usual into architrave, frieze, and cornice. The architrave is less in height than the other two members, and has the several parts disposed in the same way as they are seen in the door and window, that is to say, two perpendicular facie, the lower of which is the larger, crowned with a cimatium of an ogee, cavetto, and fillet. The frieze is adorned with bull-heads in alto-relievo, from which hang festoons of foliage, ears of corn, poppies, pomegranates, pines, rape, and bunches of grapes; and above these in the intermediate spaces there are alternately paterae and roses. The bull-heads are over every column, and between these there are two others, so that altogether they are fifty-four in number. The cornice, which is of the same height as the frieze, is composed of very elegant mouldings, well profiled. The dentil band, without any sinkings, is placed immediately over the cavetto of the frieze. The construction of the entablature consists of three courses of stones, one upon the other; the first, which forms the architrave, is of an equal number of pieces from the middle of one column to the other; the pieces of the second and third courses, composing the frieze and the cornice, are of varied lengths. Upon the architrave may be read what remains of the inscription, E. L. GELLIO. L. F.; the rest has been destroyed with the architrave itself. Piranesi measuring from the middle of the temple the distance occupied by the letters which still remain, and from this point the other which ought to have held the remainder of the inscription, upon the ruined part, he deduced that the inscription, when entire, must have been composed of only fifty letters, which he restored in the following manner:

AEDEM. VESTAE. S. P. Q. T. PECUNIA. PUBLICA. RESTITVIT.
CVRATORE. L. GELLIO. L. F.

The peristyle is sistyle, having the intercolumniation of almost two diameters, but the ambulatory is a little larger, and the floor, as I said, is sensibly inclined outwards. The ambulatory was covered with lacunaria, which rested on beams of graceful form. The ceiling is formed of many cunei of travertino, with a double row of coffers, separated by a small channel. In the centre of each coffer there is a rose, somewhat capricious, composed of one flower and four leaves, of the same mould, cutting, and style as those of the capital, with plain counterleaves. The Chevalier Valadier remarks, that the roses are not all placed with the first leaves in the diagonals of the coffer, but some are opposite and the others are placed at hazard.

The diameter of the cell is equal to the height of the column, and the wall is of that construction called by Vitruvius *reticulatum incertum*, of irregular polygonal masses of tufa with much cement. It is partly ruined towards the altar, as is the rest of the temple. The floor is lower than that of the portico, from which there was an ascent of two steps, the remains of which may be seen under the sill. In the interior, almost opposite to the door, may be seen a niche of little depth, evidently of more modern construction, and of the period of the middle ages, when the temple was converted into a church, under the name of S. Maria Rotonda. In fact, at the side of the arch there has been a cupboard of travertino to receive the little images appertaining to the new rites, and in the niche is seen the remains of pictures representing sacred figures.

The principal entrance of the temple is of travertino in various pieces, united with great skill; some vertical, others horizontal, worked into the wall of the cell. Its height, in feet, is 18 0·5, its width, at the sill, 7 10·5, and at the top 7 6·4, so that it diminishes less than is recommended by Vitruvius. The jambs have broad fascia with small mouldings, and the entablature corresponds with that of the order. In the threshold, and in the internal sides of the jambs, there are some slight sinkings, to which, according to the celebrated Uggeri, a frame was attached, perhaps of metal, to diminish the space of the doorway, to which was fixed the valve that shut up the temple. He also states that this frame was encased in the architrave (*supercilium*) for greater security, and he concludes that the two chases, one foot long, which are to be seen in the angles of the architrave, are sufficient to establish his conjecture. But Valadier judges that those traces rather served to encase a fixed metallic support with certain perforated ornaments*, a supposition much more probable, because commonly used by the ancients in similar places, as may be particularly observed in the basso-relievos.

At the side of the door, and opposite to the third intercolumniation from the middle, there were two windows with dressings, also diminishing: enclosed, according to custom, with gratings of metal. That to the left is destroyed, the other still remains very perfect. The height of the light at the outside is a little less than four diameters (109·18 inches), the width, at the bottom, is 38·6 inches, and the upper diminishes to about one-eighteenth less. The external jambs are straight, the internal have a kind of ear (*orecchiatura*) below and above, round which the fascia and mouldings pass, which, in both, are almost equal to those of the jambs of the door. The external sill is raised from the floor of the ambulatory two diameters and a half of the columns. In the entablature the frieze is omitted, and internally the cornice is much broken into small parts, whilst in the external it is more simple, and the gocciolatoja above the ogee terminates with a fascia. It appears that the skilful architect deduced the proportions of these beautiful windows from the rest of the work, but we have no precepts either in Vitruvius or any other writer.

The temple was raised upon a *stilobate* or circular basement, six feet nine inches high. The die consists of three courses of travertino, and the work is of that kind called *isodoma*. This basement, which belongs more to the monopteral than the peripteral, seems to have been employed in this case from necessity, not caprice, for the temple, being placed upon a high rock, ought to be completely seen from below, and the lower part would have been covered by the projection of the rock, if the height of the plinth had not raised it, and brought the whole into view.

Piranesi is of opinion that the temple was finished with tiles, alternately concave and convex, which were laid in the form of rays drawn from the centre of the attic. To me it appears, that the step of six inches, formed by the stones of the lacunare, is opposed to this supposition, and I think, that the cupola terminated with a flower, and not with a circular opening, to give light to the cell, as Uggeri imagined. If the cell were illuminated by an aperture in the cupola, I cannot guess why the two windows, in this case perfectly useless, were constructed.

On the ground one perceives a remnant of the staircase by which the ascent was made to the floor of the portico. Serlio, Palladio, Piranesi, Uggeri, and many others, agree that this was erected in correspondence with the great door of the temple, but they disagree in fixing the number of the steps, some maintaining there were seven,

* Mr. Donaldson, in his work on Ancient Doorways, restored the arrangement of this portal according the antique usage.

some nine, and others eleven. Valadier, after the most minute inspection made on the spot, observed that the stairs were double, and that, as well on the landing as on the steps, there was a parapet of bronze or iron, for the sake of security. I confess, that such was my opinion before I read the work of Valadier, with this only difference, that it had a curvilinear form in order the better to conform to the curvature of the temple. But having afterwards made a more careful examination on the spot, I am almost obliged to relinquish my opinion, and to acknowledge that it was straight.

The external work of the temple, as I have said, is of travertino, covered with a very strong stucco, and it must, without doubt, be attributed to the golden age of Augustus; in fact, the work cannot be either more beautiful, or in more perfect proportion, for these qualities this little temple is so distinguished by those who admire and cultivate the fine arts; and, whether it is considered as a ruin, an edifice, or an antiquity, it will always be a very pleasing object to the painter, to the architect, and to the antiquary.

The cell being of a *reticulatum incertum*, a construction adopted by the Romans in the time anterior to the empire, might induce the supposition that it was of a greater antiquity, but considering that the dressings of the door and windows are undoubtedly contemporaneous with the construction of the cell, we must abandon every doubt, and deduce that the reticulatum continued to be used in the time of Augustus, as we have visible evidence of it in the villa of Lucullus. But allowing that the cell might be of more ancient construction, this would not be a reason for excluding the external work of the temple from the golden age, for Lucius Gellius, when restoring the temple of Vesta, could have left entire the cell of the ancient construction, either because it was in a good state, or to give greater veneration to the temple itself.

Very different are the opinions of writers concerning this monument. Some, following the opinions of Cabral and Del Re, have believed that it may have been the sepulchre of L. Gellius, deceived by the remaining portion of the inscription; and into a similar error have those fallen who have supposed it to have been a temple erected to L. Gellius himself,—extravagancies which, in my belief, do not deserve confutation. There are also some, and Cluverio was the first, in his "Ancient Italy," who judge this to have been the temple of Hercules. Is it to be supposed, that in a time when the rules of Vitruvius had so much authority, that the architect should transgress one of the fundamental precepts given by that great master, in lib. 1, c. 2,—*Minervæ et Marti et Herculi ædes Doricæ fiant; His enim Diis propter virtutem sine deliciis ædificia constitui decet.* After such a positive precept, perhaps dictated by the worship, is it to be supposed, I say, that the Tiburtines should erect a temple to Hercules of a Corinthian or Composite order, whichever it may be, which is the most enriched and delicate of all others? *Credat Judæus Apella.* Besides, the ancient writers speak but of one temple of Hercules in Tibur, adorned with a long range of porticos, very rich in marbles, and which was equal, if not superior, in magnificence, to the celebrated temple of Fortune at Prænestè. Now who cannot perceive, that admitting the opinion of Cluverio, this description would have been offensive and exaggerated?

Others at last, and among these, the Father Volpi, and the Cardinal Corradino in their *Latium*, trusting the common name, attributed it blindly to the Sibilla Tiburtina. But the vulgar denomination must not be much depended on, nor is it an authority when convincing reasons prove the contrary.

It is very clear that the worship of Vesta and the ministry of the vestals were introduced in Tibur. The inscriptions which have been found sufficiently prove it. We read in Grutero, p. 1088, v. 3, the following inscription, which, from the Piazza del Trevio di Tivoli, was transported to the Villa de' Medici in Roma, where it is at present.

SAVFEIAE. ALEXANDRIAE V.V. TIBVRTIVM. CAPLATORES. TIBVRTES MIRAE. EIVS. INNOCENTIAE. QVAM. VIBA. DECREVERANT. POST. OBITUM. POSUERUNT. L. D. S. C.

The second inscription in the church of St. Antinino, now destroyed, could be read in the time of Marzi, by whom it is mentioned, as well as by Grutero (p. 315, n. 5), and the third, found in the Valle dell' Aniene, was preserved by Ligorio and Muratori (p. 172, n. 3, *Thes. vet. inscript.*)

II.

C. SEXTILIVS
V.V. TIBVRTIVM
LIB. EPHEBVS
HERCVLANIVS
AVGVSTALIS.

III.

SQVATERIAE. PRISCAI
VIR. VESTALI. MAX. SANCTISSI
MAI. PVBLIA. DECRIAN
SOROR. V.V. CVSTODIIIIIIIIII
CVRA. AGENT. IMPEND.
PVBL. P.

Maffei, Mons. Marini, Fabretti, and other authors of great repute agree that the virgin vestals and the worship of Vesta were established in Tibur. This being admitted, let us inquire whether the temple corresponds with what the ancient writers have left concerning the temples of this divinity. *Jovis, Minervæ, et Vestæ templa in medio urbium, et arcium locabantur*, says Giorgio Minutulo, *quod sicut inquit Vitruvius antequam et diserat Plato. Horum Deorum maxime in tutela videtur civitas esse.* Our temple is in the ancient citadel of Tivoli. The temple of Vesta was always of a spherical form, and such was that erected by Numa, according to the testimony of Ovid and Plutarch, and of such form is the one still remaining at Rome, and such are those on the medals of Antoninus Pius, of Mammea, of Q. Cassius, of J. Domna, as well as many others, and of the same shape is that at Tivoli. The Corinthian order was not used by the Romans in their later periods but in the temples of those divinities who were either virgins or of refined character, *quod his diis, propter teneritatem, graciliora, et florida, foliisque, et volutis ornata, opera facta augere videbuntur justum decorem.*

All these reasons—the denomination Vesta, which the place has constantly kept, and still keeps; an old picture of the fourth century, which existed in a house under the church of St. Cecilia, representing this identical temple with the inscription *Templum Vestæ;* and also the symbols sculptured on the frieze of the temple, which are quite proper, as I have said, to the goddess Vesta, induce me, with Serlio and Palladio, with the Tiburtine antiquaries, and all the most talented writers on the subject, to attribute it with certainty to Vesta. The number of engravings, pictures, and drawings made in every age of this beautiful monument, are almost innumerable, and equally numerous are the writers who have illustrated them. But with the exception of those whom I have just named, Servio and Palladio, both painters and writers seemed to conspire against this inestimable relic of antiquity, by altering the dimensions, and all its principal features, in every conceivable manner. Desgodetz himself, who, in his work, *Dell' Antichità di Roma*, cap. v., enumerates the errors of many of those who had pre-

ceded him, falls blindly himself into a still worse fault, by mis-stating the measures, forms, and ornaments, particularly of the frieze and capitals, substituting in the former skulls of stags, instead of bulls' heads, and robbing the latter of the chaste novelty that distinguishes them, attributing to them the common and ordinary form of the Corinthian capitals. Piranesi was the first to restore its true structure, but not without some errors, which were afterwards corrected by Uggeri and Valadier, by the former in his *Giornate Pittoriche*, by the latter in his *Raccolta delle più insigni fabbriche di Roma antica, e sue adjacenza*. It would be desirable that the government of Rome, which watches so indefatigably for the preservation of the ancient monuments, should exercise the same care for the preservation of this precious relic of antiquity, that a future generation may not have occasion to deplore its loss, which is probable, as the lacunari are already disconnected, and ready to fall.

REPORT ON THE TOWER OF ST. MARY'S CHURCH, NOTTINGHAM.

BY L. N. COTTINGHAM, ARCHITECT.

Vicarage House, Nottingham, January 11th, 1843.

TO THE CHURCHWARDENS OF ST. MARY'S, NOTTINGHAM.

GENTLEMEN,—Understanding that you have convened a vestry meeting on the 12th instant, to take into consideration my Report on the present state of St. Mary's church, particularly of the great central tower, I beg leave to preface the subject by inserting a copy of your letter of the 15th ult., addressed to my residence in London, which was forwarded to me at Hereford, and of my answer on the 19th; also, a letter from the Venerable the Archdeacon Wilkins, on the 21st, requesting my attendance at Nottingham, "with the least possible delay," as explanatory of my engagement with you.

"*Nottingham, 15th December*, 1842.

"SIR,—The tower of the parish church of St. Mary, in Nottingham, being considered in a dangerous state, owing to the appearance of several cracks in the main pillars which support it, a meeting of the congregation was held this morning, when it was determined to shut up the church until it had been examined by a skilful surveyor, and his report obtained thereon. The meeting fixed upon you for the purpose. The churchwardens will, therefore, be much obliged by your attendance at Nottingham, to examine the state of the tower and pillars, and to make your Report thereon, and that as early as possible, as parts of one of the north pillars have fallen during the two last nights, and created great alarm in the neighbourhood. The weight of the tower upon the pillars is supposed to be about 2,400 tons.

"I remain, Sir, your most obedient servant,
"GEORGE EDDOWES,
"Churchwarden of St. Mary's, Nottingham.
"L. N. COTTINGHAM, ESQ.

"*Chapter House, Hereford Cathedral, December 19th*, 1842.

"SIR,—In answer to your favour of the 15th instant, which was forwarded to me by yesterday's post, I beg to state that I shall be happy to wait upon you at Nottingham, for the purpose of inspecting the tower of St. Mary's church, and furnishing you with a Report on the present condition of the same. I am rather apprehensive, from the facts stated in your advice, that some very serious mischief is going on in the pier, where a part of the masonry has fallen down; in such cases it is very desirable to ascertain the progress of disruption. I therefore recommend you immediately to take a mason into the church, and request him to stop up with a little plaster of Paris as many of the fresh cracks as he can conveniently get at, cautioning him at the same time not to disturb any part of the dislocated masonry; it will then be necessary for the same man once or twice in the course of a day to look at the work. If dissolution is actually taking place in the pier, he will be able to detect it by the cracks opening in the plaster. You have done perfectly right in shutting up the church, and I need not add, that any attempt to ring the bells would be injurious. I am here superintending the propping up of the great tower of this cathedral which has been in a very dangerous state; I have now nearly made it secure, and shall leave next week, previous to which I have promised to accompany Archdeacon Wetherall to look at a tower about five miles from Hereford, which he informs me is in a very bad state; but if the dangerous symptoms in your tower increase, I will, on the receipt of further advice, immediately come over and do the best I can for you. Waiting the favour of an answer,

"I am, Sir, your obedient servant,
"L. N. COTTINGHAM.

"GEORGE EDDOWES, ESQ."

Vicarage House, Nottingham, December 21, 1842.

"Sir,—In consequence of the severe illness of both my churchwardens, I have been requested to reply to your communication. I beg to state, therefore, that I consider it of the utmost importance that you should come here with the least possible delay. I have on my own account called for the opinion and advice of one whom I consider to be the very soundest practical mason in the county—the person employed continually by our Chapter in all the works of the Collegiate Church of Southwell. Upon inspection this morning, he finds all the piers to be much shaken, and to manifest fresh crackings, and the danger is considered imminent. May I beg that you will hasten your journey hither; your nearest way is to Birmingham, and by the railroad to this place. I request that you will become my guest, and take up your abode at my house here, where I shall be most anxious to receive you.

"I am, Sir,
"Your obedient servant,
"GEORGE WILKINS,
"Archdeacon of Nottingham."

In compliance with the Archdeacon's request, I immediately left Hereford, and arrived at Nottingham on Saturday the 24th. The Archdeacon and one of the churchwardens accompanied me to the church (the other being, as I was informed, too ill to attend). A very short inspection of the four main piers was sufficient to convince me that the great central tower of the church was in the most imminent danger. Cracks and fissures of the most alarming description presented themselves in various parts of the piers, so as to leave no doubt on my mind that the most dangerous disruptions were rapidly taking place, and that, if not immediately arrested, the fall of the tower in a very short time would be inevitable. On communicating my opinion to the parties present, the Archdeacon anxiously inquired if security could be given to the fabric, without endangering the lives of the workmen. I informed him that there would be some risk, but that I was ready to undertake the task, and personally superintend the works necessary to be performed. Workmen were immediately sent for, to whom I stated my fears, at the same time requested them to keep a sharp look-out, and, in case of need, retreat as soon as possible through the west end doorways, taking care to leave all passages of egress clear of every kind of material which might impede their escape from the church. I then directed them to clear away the whole of the pewing under the tower, standing myself amongst them, anxiously watching what I considered the most dangerous parts of the edifice. The pews being taken down and the floors removed, a quantity of timber was promptly procured. I then gave directions for fixing a series of cross strainers from pier to pier under the south arch of the tower.

A portion of these were fixed by ten o'clock that night, and the workmen were ordered to attend, from the extreme urgency of the case, on the Sunday morning at an early hour, which they did. During the Saturday night and throughout the whole of Sunday fresh cracks were observed, and many of the moulding ashlar stones of the piers had shivered to pieces. I then directed my whole attention to the south-east pier, against which the south wall of the chancel and east wall of the south transept abut; here dissolution was evidently going on very rapidly. Upright abutment timbers were set against the stone shaft under the eastern arch, and cross strainers inserted with all possible expedition. A similar operation was performed under the north and west arches; these being completed, I next gave my attention to the shafts of the piers in a diagonal direction, evident symptoms of disruption having appeared to make that step necessary. These being secured with strong trussed timber strainers, I found, to my very great concern, that the exterior angles of the tower at the north-east and south-east corners had given way. Two lifting shores of strong timber, 14 inches square, shod with iron at each end, were immediately inserted, and wedged up with iron wedges, taking care to place thick pieces of felt between two sheets of lead, under the head of each shore, to prevent the stone flushing from the pressure. These

works being duly performed, I considered the tower in a sufficient state of safety to warrant my proceeding with an examination of the foundation of the piers. For this purpose, I caused an excavation to be made round the bases of the western piers about seven feet in width, down to the sandstone rock on which the tower is erected. The rock is very uneven on which the piers stand; varying in depth from the level of the pavement round the piers, from four to six feet; and it does not appear that any level setsoff were cut when the foundations were laid, the stones of which consist of various fragments of a much earlier building, probably Saxon, or very early Norman. They consist of capitals, shafts, bases, arch-mouldings, and plain ashlar of a strong grit stone, and are in excellent preservation, packed together in a tolerably sound manner with very little mortar, and brought to a level by long and short stones as the dips of the rock might require. The top of the rock is very soft and shaley; it easily scales off in pieces from one to two inches thick, and from six to twelve inches square, and may be crushed to powder between the finger and thumb with the slightest pressure. On reaching this, I was greatly alarmed to find that a number of graves of ancient form and character had been sunk all round these piers, from fifteen inches to four feet below the lowest stones of the foundation, to obtain room for which, the angles of the stone work had been cut off, and the whole of the spreading footings removed, except a few stones at the south-east corner of the south-west pier. The bodies were all decayed, and the graves, seventeen in number, full of loose mould, except three which had lead coffins in them. These being carefully removed, the top of the rock presented the most awful state of insecurity I ever witnessed; the edges of the graves were crumbling in from the pressure of the tower above, which threatened every moment to crush the fragile matter on which it stood to atoms. No time was to be lost here; I instantly directed a stage twelve feet high to be erected over these excavations, which in a few hours were filled up to the level of the original rock with a strong concrete. The defective angles of the foundations were then made good in solid masonry, the mould and loose mortar carefully raked out of all the chinks and interstices, and a strong grouting, composed of Parker's cement and sharp grit sand, poured in. The whole area of the excavation made round the south-west pier was then filled up to the level of the underside of the pavement with concrete, and the same was extended to as much of the north-west pier as was deemed necessary for its immediate security. The workmen were then directed to excavate the ground round the eastern piers of the tower internally and externally. On removing the earth from the external angles of the quoins of the tower, similar graves to those already mentioned, were found in the soft rock, three feet six inches below the lowest stones of the foundation, at the south-east angle, and close against the walls of the chancel and south transept: these have been filled up with concrete. At the north-east angle of the tower graves of long formation were also found below the foundations, and one ancient family vault was found for which two feet of the original foundation had actually been cut away directly under the quoin of the tower! These deficiencies in the foundation have likewise been filled up with concrete thrown in from a high stage. The above, which form essential parts of substantial reparation, have been made to the building by a necessity which admitted of no delay. I next proceeded to examine the internal foundations of the eastern piers,—these are built with ashlar stones, probably taken from the same ancient building as the stones used under the western piers; the faces of many of them have been painted in distemper in various colours, such as blue, red, &c. These fragments are built up without mortar, and but slightly bonded on the face; one of the angles has an upright joint throughout. On raking out the sand and mould from the vertical joints, these foundations proved to be in a very insecure state, many of the stones being broken from the pressure above. No time should be lost in repairing these defects, and filling up the trenches around them with concrete, which will bind the work together, and prevent any further bulging. I next proceeded to examine the masonry of the four main piers. They are built in the perpendicular style, with slender shafts and faintly cut mouldings and arrises on the face; the centre or core is filled in with stone chippings and mortar; the height from the floor line to the top of the moulded capitals is twenty-eight feet ten inches, and the diameter at the bottom of the bases seven feet eight inches. These piers have a light and elegant appearance, but the masonry is not sufficiently bonded into the rubble core to carry with safety the weight of the tower. The moulded facing in many parts is not more than eight or nine inches thick. Several defective stones being cut out, enabled me to inspect the beds of the masonry, which in every instance appeared to have been overloaded, being split and shivered in various directions, particularly the south-east pier, with which the walls of the chancel and south transept are connected. This pier, in settling down, has broken and crushed every stone in the walls attached to it, so that small rods may be passed through in various directions. The ashlar of the pier is also in a very shattered state, many of the stones being split and shivered into seven or eight pieces, in a vertical or slightly inclined direction, which proves that no attention was paid to the natural beds of stone when removed from the quarry,—a thing of the utmost importance in buildings erected in the manner of this church. The four arches, which spring from the tops of these piers, are very lofty and graceful, but they have been sadly mutilated by cutting away the mouldings to receive the timber work of some modern barbarous plaster ceilings. One half of the arches abutting against the tower, at the east ends of the north and south aisles, have sunk down with the tower piers; these must be taken out and restored to their proper position. The tower, consisting of two stages above the church roof, is crowned with a good battlement and eight wirey *modern* pinnacles; one of which was lately blown down on to the roof, and it is satisfactory to know that the others will soon follow if not taken off. The restoration of these pinnacles in proper character will greatly add to the strength of the battlement, for which reason they are included in my estimate. Several recent cracks have shown themselves in various parts of the walls, but I am of opinion that any further movement may be completely counteracted by the introduction of three tiers of cast iron chain ties inside the walls, as shown on the plans herewith exhibited. The present iron ties are of no use whatever, and are besides exceedingly unsightly, the weather mouldings having been cut away to receive the iron plates, which disfigure the exterior of the fabric, and convey to the mind of the spectator an air of weakness instead of security. No doubt great injury has been done to this noble tower by ringing the bells when the fabric was known to be in a very tottering state, and I found it necessary to leave the strongest injunctions against the very least repetition of this until the repairs of the tower shall be completed. There is a very large brick vault on the east side of the north transept, abutting on the pier of the tower, which has tended to weaken that part of the fabric: a portion of this must be removed to make room for the concrete. It is a fortunate circumstance that the sinking of the masonry in the four piers of the tower has been nearly uniform; there is not more than an inch and a half difference, the western piers having sunk so much below the others. The body of the tower is nearly perpendicular. Had a more partial settlement taken place at either angle, I am of opinion the tower must have fallen. The stone piers of the nave are very slender and somewhat out of the upright, leaning towards the west.

This beautiful fabric has a very large proportion of window, equal if not superior to any church in England. It has been repaired, or rather mutilated, from time to time by substituting bricks, tiles, mortar, and compo, for solid stone work; the clerestory windows in the nave have been denuded of their intermediate mullions and tracery, and now present a disproportioned glaring breadth of plain glazing and iron bars; the reinstatement of these would greatly add to the strength as well as the beauty of the fabric; the performance of which is not included in my estimate.

The oak timber roof over the nave was originally open to the church, but is now excluded from the sight by a monstrous plaster ceiling, which, by keeping out the air, has been the means of promoting the rot which now affects a great portion of the timbers; this should be immediately removed, and the rotten tie-beams and rafters repaired and restored; it is at present in a very dangerous state, and might fall in through the flimsy ceiling without an hour's notice.

On taking down the plaster ceiling in the chancel, which was more ugly if possible than that of the nave, a great portion of the original oak roof was found; it is a very chaste design, but sadly decayed in the main timbers, which has been facilitated by the exclusion of air from the ceiling; the joists were found too slight and loose to admit of any one going very minutely into this part of the work, but I saw enough to convince me the roof is in a very dangerous state; the ceiling joists should be immediately taken down, as they are not safe to walk under; one of them fell during the examination of the roof upon the shoulder of a workman below: had it fallen on his head he must have been killed on the spot. The removal of a very inappropriate attachment of modern wainscotting at the east end of the chancel has fully developed the lower compartments of a beautiful window, and brought to light the remains of three sedilia and a piscina; the restoration of these would greatly add to the beauty of the chancel.

I trust that the arduous duty I have been engaged in, and the shortness of the time, will plead a sufficient apology for my not going fully into minutiæ as regards the estimated expense of the re-

pairs and restoration of the tower and roof over the nave, but as my calculations are founded on the admeasurement of the principal parts, and are the result of thirty years' practical experience in similar works, I am confident they will be found near enough for the present purposes.

A substantial reparation and restoration of the tower, with eight new stone pinnacles of the original size, and three tiers of cast iron chain ties, including the shoring up and the reparation of the foundations already performed, will cost about two thousand four hundred and forty pounds. The architect's per-centage, journeys, and expenses, in addition to this survey and report, may be estimated at £210; for the clerk of the works, £100. The reparation and restoration of the timber roof over the nave will cost about four hundred and seventy pounds; making a total of £3,220.

I have the honour to be, gentlemen,
Your very obedient servant,
LEWIS NOCKALLS COTTINGHAM, Architect,
Waterloo Bridge Road, London.

REPORT ON THE TOWER OF ST. MARY'S CHURCH, NOTTINGHAM, BY MR. S. J. WALKER AND S. S. RAWLINSON, ARCHITECTS.

Nottingham, December 13th, 1842.

TO THE VENERABLE ARCHDEACON WILKINS, D.D.

Reverend Sir,—We beg to report, that in obedience to your directions, we have duly surveyed and examined the tower of the parish church of St. Mary, and that we are of opinion, that the south-eastern and north-eastern piers of the arches from which the said tower is carried up, have been built on insecure foundations, and have sunk in consequence; that by such sinking, the equilibration of the tower has been destroyed, and an undue pressure thrown on the aforesaid piers. We are of opinion that such pressure exceeds the amount of resistance that the stone of which the piers are built is capable of opposing to a *crushing force*. This opinion is founded on an experiment which we have made on a favourable specimen of the stone referred to, and on the appearance of the piers; the *vertical cracks* in which shew that they have been subjected to a force which has overcome the cohesion of the stone of which they are built. We find that in consequence of the sinking above mentioned, the arches abutting on the aforesaid piers have been displaced, and have subjected the said piers to lateral thrusts, which have forced them from their proper perpendicular or vertical position, and occasioned much inequality in the distribution of the pressure of the superstructure of the tower upon the heads of the piers, whereby the masonry of which they are composed, has been crushed in detail. We find the masonry of the tower unsound and displaced, resulting from the sinking of the piers, and the dislocation of the arches on which it is built.

We are of opinion that *imminent danger is to be apprehended from the present state of the aforesaid piers and tower*; and although we are not prepared to say how long they might continue in their present condition, we wish it to be distinctly understood, that we are of opinion that they ought not to be permitted to continue in such state, with the expectation of their manifesting further symptoms of instability, or of further warning of approaching dissolution being given:—we apprehend that whenever further symptoms of instability are manifested, they will be immediately followed by the destruction of the piers, and the consequent fall of the tower, which would in all probability render the church a ruin.

As ringing (by the oscillation of the tower which it produces), subjects the piers to an impulsive force vastly greater than calculation enables us to hope for their sustaining in their present enfeebled and insecure condition, we earnestly recommend its immediate discontinuance.

Being of opinion that the extremity of the case was not apprehended, when we received our instructions to make our survey, and submit such remedy as we might be disposed to recommend, with the estimate of the probable expense of carrying the same into effect; to do which it would be necessary to make many admeasurements, and to enter into a large amount of constructive details, which would involve considerable expense, we have deemed it our duty to deliver in our *report on the present condition* of the piers and tower, and to defer the consideration of the remedy until we are honoured with additional instructions. We have been further induced to adopt this course from being of opinion that the expense of carying into effect the only mode, which we have as yet been able to devise, for securing the present structure, would be fully equal to one-third of the expense of taking down and re-building.

We are, Reverend Sir, your very obedient servants,
S. J. WALKER, } Architects.
S. S. RAWLINSON, }

THE ATMOSPHERIC RAILWAY.

IT will be in the recollection of all our readers that, in consequence of an admirable letter addressed by Mr. Pim, the treasurer of the Dublin and Kingstown Railway, to the Earl of Ripon, President of the Board of Trade, explaining the principle of the Atmospheric Railway, and praying for an authorized inquiry into its merits, Lieut.-Colonel Sir Frederick Smith and Professor Barlow were appointed "to inquire into the application of the atmospheric principle in producing locomotion on railways," and to report thereon. The appointment of these eminent men gave general satisfaction to all who, like ourselves, felt an interest in the investigation, from a conviction of the applicability of the principle, and of its ultimate value to the traffic of the country. Never was an invention of equal importance examined under circumstances so disadvantageous, and with arrangements so inadequate; and when this was taken into consideration, it was not a matter of surprise that the Commissioners in their Report of the 15th of February, 1842, found some objections. The public, however, was startled to find that they had come to conclusions so favourable to the adoption of the principle.

"Having thus stated," they report, "the views we entertain on this subject, and having given in the Appendix the exprimental results, and the investigations on which they are founded, we beg to state,

1. "That we consider the principle of atmospheric propulsion to be established, and that the economy of working increases with the length and diameter of the tube.

2. "That the expense of the formation of the line in cuttings, embankments, bridges, tunnels and rails will be very little less than for equal lengths of a railway to be worked by locomotive engines, but that the total cost of the works will be much greater, owing to the expense of providing and laying the atmospheric tube, and erecting the stationary engines.

3. "That the expense of working a line on this principle on which trains are frequently passing, will be less than working by locomotive engines, and that the saving thus effected will in some cases more than compensate for the additional outlay, but it will be the reverse on lines of unfrequent trains. However, there are many items of expense of which we have no knowledge, and can form no opinion, such as the wear and tear of pistons, valves, &c.; on these further experience is needed.

4. "That with proper means of disengaging the train from the piston, in cases of emergency, we consider this principle as regards safety equal to that appertaining to rope machinery. There appears, however, some practical difficulties in regard to the junctions, crossings, sidings, and stoppages at road stations, which may make this system of less general application.

"We may add that the atmospheric principle seems to us well suited for such a line as the projected extension from Kingstown to Dalkey is represented to be: we should have been glad if this line had been three miles, instead of only one mile and three quarters

in length, as it would then have brought this principle to a more complete and decided test."

From this abstract of the opinions of Sir Frederick Smith and Professor Barlow, it will appear that the chief objection in their minds was the cost of forming the line, although this is partly met by the admission that the small expense of working in some cases will more than compensate for the additional outlay. But the recommendation that the principle should be tried on the Dublin and Kingstown railway, and the expression of regret that the extension to Dalkey is not three miles in length, is a tacit admission that the trials they had made were not adequate to the full determination of the question they were appointed to answer.

The directors of the Dublin and Kingstown railway being fully convinced of the adaptation of the atmospheric principle to a projected extension to Dalkey, recommended its adoption to the shareholders, and on the representation of the Board of Public Works for Ireland, the Commissioners of Her Majesty's Treasury authorized a loan to the company of £25,000 for the execution of the proposed line, which is now so far advanced that there is a probability of its completion in the spring of this year.

Professor Barlow's report, and subsequently, the adoption of the principle upon the Dublin and Kingstown railway, necessarily drew the attention of scientific men to the subject, and many engineers, among whom we may particularly mention Mr. Vignoles, the professor of engineering at the University College of London, having carefully examined the subject in all its bearings, not only expressed themselves satisfied with the principle, but strongly contested the conclusions somewhat hastily drawn by the Government Commissioners. During the last month a pamphlet has been published by Mr. Bergin*, in which their conclusions have been more fully tested, and the whole subject has been admirably examined. To this we are now anxious to draw the attention of our readers.

"The report," says Mr. Bergin, "contains two classes of observations; firstly, those which are the result of experiments instituted by the reporters, and of theoretical investigations founded on these experiments; and, secondly, those which are, more properly speaking, matters of opinion only. The latter will be hereafter discussed; but the former, namely, the experimental, and especially the theoretical investigations, sanctioned as they are by the very high authority of Professor Barlow, as a mathematician and experimental philosopher, demand the earliest attention. It is with very great diffidence indeed that I differ from my respected friend on a subject involving mathematical attainments, in which he is so rich, and to which I have no equal pretensions; nor would I have ventured to do so at all, were it not that having observed the omission of data to which I have alluded, I found that introducing them into the theorems would materially modify the conclusions of the reporters. The importance of the inquiry, and, I may add, the approbation of a scientific friend, the Rev. Dr. Robinson, of Armagh, to whom I have communicated these 'Observations,' will, I hope, be sufficient excuse for me."

The first subject alluded to by Mr. Bergin, is the value of the unit of horse-power used by the commissioners, which they assume to be 33,000 lbs. raised one foot in a minute. "Every such nominal horse-power," they say, "may be considered as capable of raising 58,000 lbs. one foot in a minute, and after deduction for the friction of the air-pumps, of still exhibiting at the working point 52,000 lbs., consequently, all our numbers require to be reduced in the proportion of fifty-two to thirty-three, to obtain from them the nominal horse-power requisite for producing any of the proposed results." To this Mr. Bergin very properly objects, as calculated to mislead the public upon the important question of the cost of the engines to be used on an atmospheric railway.

"If it be asked," he says, "what consequence which of these units be adopted, they being but different modes of expression for the same amount of power?—the reply is, that the *nominal* horse-power is not only that exclusively recognized and used by engineers for the performance of engines, but it is also the *commercial* unit by which the *cost* of engines is regulated. And hence it is important to direct particular attention to the reduction of the reporters' numbers; and the more so, because, in the Report, at page 8, much stress is laid on what may be called the converse, namely, that by using the *subsequently admitted unrecognized* unit, the engine at Wormwood Scrubbs which, commercially, is of 16-horse power, would, according to the reporters, really be of 25 or 26-horse power, and, consequently, to erect such an engine, with the air-pump, would cost about £1000, instead of £640, or thereabouts. When I come to treat of the engine-power necessary for long lines, it will be obvious how very erroneous an impression as to the amount of capital to be expended is conveyed (however unintentionally) by the reporters' having adopted a measure of horse-power which is not recognized by engine makers. It may also be desirable to explain the probable source of this error, as it is generally understood that steam-engine horse-power is a certain definite quantity of work done, such as could be performed by a horse, whereas, in fact, it is a conventional expression for the dimensions of a steam-engine."

This objection is in every respect tenable and just, and was necessary to prevent a mistake as to the cost of engines upon the atmospheric railway. It is an instance of what frequently occurs in scientific nomenclature—the continued use of a term which, when adopted, was supposed to be founded on a scientific truth, and which is retained with a conventional meaning. Thus the pole of the magnet, which turns to the north pole of the earth, is still called the north pole, though every one knows, since the principle of induction has been developed, that it is in fact the south. So in the time of Watt the unit of horse-power, that is, available power, was considered as equivalent to 33,000 lbs. raised one foot per minute, and upon this he established the proportion of the several parts of engines. The same term is still retained, and the power of an engine is calculated in the same manner, although it is well known that the available power is more nearly represented by 55,000 lbs. raised through an equal space in the same time, "or making ample deductions in the present case for the friction of the exhausting pump, there remains," as stated in the Report, "an available power of 52,000 lbs. or upwards."

There are three distinct questions upon which Mr. Bergin disputes the conclusions of the government reporters, to which we can at the present time only very generally allude.

1. "The expenditure of engine power necessary to maintain any given amount of exhaustion already obtained in the working main." In commencing with the investigation of this subject, Mr. Bergin attacks the very foundation of Professor Barlow's report, and in exposing the error throws a doubt over all the succeeding deductions and calculations.

"It was necessary, in our case," say the reporters, "to ascertain the actual power of the engine at its working point, namely, its actual lifting-power, after overcoming its own friction and that of the air-

* Observations on the Report of Lieut.-Colonel Sir Frederick Smith, R.E., and Professor Barlow, on the Atmospheric Railway, by Thomas F. Bergin, M.R.I.A.

pump piston. With this object the carriage was sent to the end of the line, and its piston inserted in the pipe. The carriage being then retained by its break, we ascertained experimentally the number of strokes that were necessary to sustain permanently and steadily different degrees of vacuum, varying from 15, to others of 22 and 23½ inches," of mercury.

To the mode in which the experiments were performed, Mr. Bergin does not object, but he justly complains that deductions should have been drawn from them as though they had been experimenting with a theoretically perfect machine, making no allowance for the wretched pump with which they were working. Mr. Bergin's objections are so tersely stated, and are so conclusive, that we feel compelled to quote them at large :—

"A slight examination of the process of computation, which is given in some detail, shows that the reporters considered the air-pump as being *absolutely perfect*, that is, that its valves opened without resistance, and that there was no space whatever left between the piston and the pump-cover at the end of the stroke, or, in other words, that when the piston receded from the pump-cover, and, until the valve communicating with the receiver or main to be exhausted opened, there was an *absolute vacuum*. From such an imaginary instrument, they compute the mean pressure on the air-pump piston, corresponding to the height of the column of mercury in the vacuum gauge, and taking this as the measure of effect, they calculate back to find the power which should have been expended by the steam engine to overcome this calculated resistance, using Watt's unit of horse-power, and then applying these deductions from a *theoretical* apparatus to the actual pump in use at Wormwood Scrubbs, which it will be presently seen does not fulfil any of the assumed conditions; and without inquiring how far this pump is from the perfection calculated on, and consequently without making any allowance whatever for its defects, they at once charge all the strokes which it had to make more than would have been required from a perfect instrument, as so much power inevitably wasted by the invention, and from this obviously incorrect estimate they go on to calculate the expense of working, and the length of main which an engine can exhaust.

"Now, what is the fact? The air-pump at Wormwood Scrubbs is so far from fulfilling the conditions of perfection assumed by the reporters, that its valves require a pressure or force to open them, amounting, on a mean of several experiments, to 1·263 inches of mercury, or more than six-tenths of a pound per square inch of piston surface, and the whole capacity of the pump being 16·45 cubic feet, the space traversed by the piston during the stroke is only 14·373 cubic feet, leaving at each end a waste space of 1·038 cubic feet, or about one-sixteenth of the whole capacity, which spaces must at all times, during the working of the pump, remain filled with air of density greater than that of the atmosphere by the force required to open the valves, and which dense air, when the piston recedes from the cover, expands, and in part occupies, the space which ought to be filled with air from the main, and be forced out at the return stroke, thereby diminishing the exhausting power of the pump. The actual amount of loss thus sustained will be subsequently calculated."

Mr. Bergin then proceeds to show the true mean pressure in pounds per square inch on the air-pump piston, for each inch of mercury, as shown in the vacuum gauge, and to compare his results with those of Professor Barlow, and from this it appears, that by omitting to allow for the imperfections of the pump, the correct mean pressure on the air-pump piston is not given in any one case, and for the higher degrees of exhaustion is doubled. In the same manner Mr. Bergin contrasts in a table the horse-power required to maintain a steady exhaustion, or, in other words, to compensate for leakage, according to the Professor's formula, with the true *nominal* or *commercial* horse-power, according to his own calculations, and proves that in four cases it rises from 63 per cent. to nearly fourfold. The effect of this error upon the calculations of Sir Frederic Smith and Professor Barlow, is forcibly stated by Mr. Bergin.

These "differences in excess are rather serious, and the more so if it be kept in mind that, by the reporters' mode of separating the *variable* from the *constant* leakage, much the greater part of the whole amount is, in their statements, necessarily thrown into the former; and as these results are deduced from experiments on only half a mile of main, they would become very important indeed when extended to lengths of some miles; for instance, in the report, page 10, it is stated, that with a vacuum of 18 inches, and a three-mile main, the whole leakage (the exhaustion having been previously produced) would amount to 62-horse power, of which 2·48 would be the constant part due to the piston, and 59·52 the variable part dependent on the long valve and joints, or, extending the same mode of calculation to lengths of five miles, which I believe will be found to be about the most convenient as well as advantageous distance between the pumping engines, and agreeing with the reporters, that the leakage power is that which ought to be provided, in addition to the discharging power, the maintaining power for 18 inches of exhaustion would be a total of 101·7 of their horse-power, of which 2·48 is for the piston leakage, and 99·22 for that of the long valve and joints. Now, correcting this for the excess of the reporters' estimates of mean pressures and leakage; again for their unit of horse power; and, finally, for the proportions of *variable* and *constant* leakage, which I find to be as *two* to *one*, instead of *four* to *one*,—we have as the final, and I believe, correct result, that the power for five miles of 9-inch main, at 18 inches exhaustion (exclusive of discharging power), instead of 101·7 horses, would be but 49·7, of which 2·4 is for the piston leakage, and the remaining 47·3 for that of the valve and joints. Or, if 21 inches be assumed as the working exhaustion, which I think not improbable on lines with those *steep inclines* which the atmospheric principle admits of, or for increased loads (still exclusive of the discharging power), instead of 164 horses, which, according to the Report, would be indispensable, would be but 69·3 horses. These results are drawn from the reporters' experiments and statements, which, however, show a *total* leakage about *four times* that deduced from the experiments of the 22d April, 1842, recorded at page 82 of these observations. I am not aware of the mode of experimenting used by the reporters, therefore cannot trace the probable cause of this great difference, but it is not too much to assume that what was done on the 22d April, *without preparation*, may reasonably be expected on a line regularly worked, and, of course, regularly attended to, and consequently the above corrected "leakage-discharging powers" may be expected to be reduced to one-fourth; that is, to prove, in practice, not even 49·7 or 69·3, but only about 13 and 18, instead of 101 and 164 horse-power. Either, however, is a very important difference, when it is kept in mind that the power necessary to counteract the leakage, much more than the "discharging power," influences the distance at which the pumps may be placed apart; and, consequently, not only the amount of capital to be expended on engines, but also the future working expenses of a line of railway on the atmospheric principle. The following up of this part of the subject, however, more properly belongs to the third point noted for inquiry; but, before proceeding further it is right to say, and it must be kept in mind by those who have so far accompanied me, that these 'leakage-discharging powers' are alto-

gether deduced from the actually existing apparatus at Wormwood Scrubbs, and give little certainty as to the requirements in future constructions."

From these observations it must, we think, appear that Professor Barlow has greatly over-stated the power required to counteract leakage, and maintain exhaustion, and consequently has over-estimated both the original cost of the railway, and the expenses that will attend its working.

2. Mr. Bergin next proceeds to examine "the power absorbed or expended in producing any desired vacuum in the working main; involving in this step of the inquiry the discharging or exhausting power of the air-pump, and the waste of power by reason of the leakage of the whole apparatus." The mode of calculation adopted by the reporters to determine this question was evidently unfair, for they first calculated the number of strokes required to produce a given degree of exhaustion by a perfect pump, and this number they compared with the number of strokes required to give the same result with the working-pump, and the difference they considered as the power required to supply the loss resulting from leakage. But the pump was not the perfect machine with which it was theoretically compared, but one acknowledged, even by themselves, to be unfit to test fairly the real value of the invention. It is not stated by Professor Barlow in what manner the further extremity of the main was closed during his experiments, whether by the entrance valve or by the travelling piston. If by the latter, another error enters the calculation; for, as stated by Mr. Bergin, it was contrary to the mode of working the atmospheric railway, in which the main is closed by the entrance valve, and not by the travelling piston, when producing the vacuum.

3. The third proposition which Mr. Bergin proposes for discussion is, the determination of the part of the entire leakage, which, being due to the travelling piston, is *constant* for the same degree of exhaustion, whatever length of main be in use; and of the part which is variable, being due to the long valve and joints, and consequently dependent on the length of the main. The applicability of the principle being determined, this is without doubt the most important subject of investigation, as it involves the amount of engine power required, and therefore embraces the cost of working as well as of constructing the line.

"The method adopted for this purpose," says Mr. Bergin, "as set forth in the Report, was to observe the number of strokes of the air-pump required to maintain any given vacuum, when the long valve was of the whole length, and when it was reduced to three-fourths and to one-half; and from these numbers is deduced, by inspection, the relative proportions of *constant* and *variable* leakage for half a mile of main. By this mode of proceeding the reporters have arrived at the conclusion that the leakage of the long valve is four times that of the piston; but the whole procedure is incorrect, not only in the *mode of experimenting*, but also in the *principle of the computations* founded thereon. The observations are not right, because it is obvious the whole leakage of the air-pump pistons, be it much or little, is included with that of the long valve and travelling piston; and as to the principle of computation, the reporters overlook the fact, that as they diminished the space to be exhausted, they altered the ratio between the space and the pump, and of course varied its discharging power; consequently the number of strokes is no longer a measure of leakage."

It is difficult to find a satisfactory apology for the commission of these blunders, for one cannot imagine how men accustomed to the performance of scientific experiments can, without great negligence and carelessness, have so ill performed the duties for which they were selected. The want of time and space has prevented us from entering upon such an examination of the several subjects brought under our notice by Mr. Bergin's pamphlet as they deserve, and as we are inclined to give; it was therefore thought desirable to confine ourselves simply to Mr. Bergin's statements, as we may have a future opportunity of discussing each error in particular, and of estimating from correct principles the true value of the Atmospheric Railway.

Since the publication of Mr. Bergin's pamphlet there has been a correspondence between that gentleman and Professor Barlow. By Professor Barlow's hasty publication of one of his letters in the *Railway Times*, it became necessary that the correspondence should be made public, and for that purpose we have been favoured with a copy of the letters, and such general remarks as seemed necessary so to connect them as to render them intelligible to the reader.

Extract from a Letter to Professor Barlow, dated 11th Sept. 1842.

"With respect to the Atmospheric Railway, the contract was signed with Samuda Brothers on yesterday, as well as that for forming the way with Dargan. All other preliminaries have been arranged, and it is probable that within the next ten days the works will have commenced, and will, I hope, be in full operation before the 1st May next. Touching this matter, I need hardly say with what anxiety I looked for your report, nor with what attention I read it.

"At the time I ventured to differ somewhat in opinion with you, believing that even on the data afforded by the wretched specimen at Wormwood Scrubs, the thing will realize considerably more than you predict; and that in fact, at the time, the total expenditure of power, as well as the quantity wasted by leakage, was not so much as you deduced.

"At the time I desired Samuda to try a few experiments for me, which he did; but I was not since able even to look at the papers, until during my recent absence from home I took them with me, and went into the subject with a good deal of care.

"I am now throwing the results together, and when finished, I will submit them to you."

After this letter, I did not hear from Professor Barlow, nor had I any correspondence with him, until my "Observations" were finished, when, as the most respectful course, I sent him a copy in manuscript, with the following letter:—

MY DEAR SIR, 8, *Westland Row, 26th Dec.* 1842.

So long since as September last I mentioned, (when replying to some queries as to the performance, &c. of our hydraulic ram,) that I was occupied in examining the principles of the "Atmospheric Railway," and that so far as I had then gone, I differed as to the results from you and Sir Frederick Smith. A variety of circumstances of a personal nature, including a good deal of absence from Dublin, and no trifling share of ill health, considerably delayed my inquiries; and it was not till a short time since I was able to complete these inquiries, of which I now beg to hand you a copy.

It is with great reluctance I feel myself compelled to differ from your conclusions, and I have taken the utmost pains to see whether I was right. Having fully satisfied myself on that point, and feeling that I was considerably involved in the question of the probable results of this experiment, I have not hesitated to publish my conclusions; and most sincerely do I hope that my doing so will be taken by you as it was intended, an honest inquiry after truth. This was your and your colleague's object, as it must be that of every rightly disposed man.

The invention, if not *decidedly* good, must be deemed a failure; doubtful results will not answer; committed as I was and am to it, I have not spared any pains in my inquiries. Your experiments and investigations were the starting point for mine, and the results are now submitted to you.

To me it would be a cause of deep regret indeed, were I the cause of one moment's annoyance to you; but I cannot believe it; the sincere desire of the philosopher must ever be for truth.

Believe me, my dear Sir, with sincere respect,
Yours very faithfully,
T. F. BERGIN.

On the 9th January instant, I received the following letter from Professor Barlow:—

Woolwich, January 6th, 1843.

DEAR SIR,

When I wrote to you on the 3rd instant, I stated that I was just leaving Woolwich for a short time; but a circumstance subsequently occurred which delayed my departure; and I have availed myself of it to look over your letter to Mr. Low, and I am bound to say that I do not find in it anything to alter my opinion, as to the correctness of Sir F. Smith's and my deductions respecting the atmospheric principle of locomotion.

I cannot attempt to go over, step by step, the several objections you have raised, but I will refer to the principal of them.

Your objections respecting the unit of horse-power we have employed, seems scarcely to call for observation. Every one knows that Watt fixed this unit at 33,000; but the perfection at which the engine has since arrived, has enabled makers of the present day to produce a much greater effect than he did at the time this unit was fixed from an engine of the same dimensions; and that instead of 33,000, effects amounting to from 50,000 to 60,000, or even more, are frequently arrived at, varying according to the skill and manipulation of the maker. We therefore used Watt's unit of 33,000 as that most generally recognised, and have finally given what we considered to be a fair ratio for deriving from it the actual power or dimensions of the engine required for producing any given effect. With this ratio you seem well satisfied; but as a matter of opinion or taste, you think it should have been introduced in an earlier part of the report. As, however, the whole investigation is contained in fourteen pages, I cannot think this a matter of much importance.

We come now to your first objection to our principle of experimenting, viz.—that the stroke of the air-pump was only 22½ inches, whereas the air-pump cylinder was intended for a two-feet stroke, and you thence conclude that more than, or at least, 1½ inch of air remained in the cylinder, which we neglected to consider; but I have already, in my letter to you of the 3rd instant, informed you that the 1½ inch space, which you assumed to be filled with air, was filled with a wooden false bottom*, in order that all the air might be expelled at every stroke, or at least all that was possible. This fact, which you do not appear to have been aware of, of course altogether sets aside the deductions you have drawn from our supposed omissions, and has been the cause of the principal discrepance between us. The weights of the valves we certainly did not take into account; but I must observe, that if the merit of the invention rest upon so minute a point as this, the advantages of it would be of a very doubtful character, which I hope is not the case.

I am rather surprised that you did not suspect some error in your formula or in your data, when you found, as in table 2, page 16, that the force expended to support a vacuum of 23½ inches for the whole length of the pipe, requiring 42 strokes per minute, amounted to only 9.8 horses' power. The engine at this time was certainly doing all it was capable of, viz., exerting the full force of 16 horses (of (52,000); so that, according to your result, two-fifths of the power of the engine you must have supposed to have been lost, which is rather a large deduction for profitless power. Whereas, our 26.2 horse-power (of 33,000) reduced according to our ratio, gives just 16 horse-power, as it ought.

I shall only further notice another of your objections, viz.—that of separating the constant from the variable leakage. On this head you observe, page 24, "The reporters overlook the fact, that as they diminish the space to be exhausted, they altered the ratio of the space and the pump, and of course varied its discharging power." Now it is certain we diminished the space, as is here stated; but as the leakage of the pipe supplied the air exactly as fast as the pump exhausted it, the diminished space could have no effect. We were constantly working against the same pressure, viz.—with a constant vacuum of 21 inches in all the cases used for comparison, and the results would have been the same, even with an indefinite atmosphere of the same density.

I must request that you will consider this letter as a reply to your communication, as I am not sufficiently at leisure to enter more fully into the question. Fortunately, the time is not far distant when we shall have an apparatus at work, that will enable us to decide between the accuracy of our respective deductions. I will not say that I shall be glad to be found wrong to the extent you have imputed; but I shall be well pleased to find that at least our report will be borne out by practice; and if we have erred, that the error may be found on the side of prudent anticipation.

* The cylinder was opened in our presence.

With my best wishes for the successful result of your forthcoming important experiment,

I remain, dear Sir, yours very truly,

PETER BARLOW.

To this letter I replied at once, viz.:—

48. *Westland-row, Dublin, January 9th*, 1843.

MY DEAR SIR,

I am this morning favoured with your letters of the 6th and 7th instant, the former of which you wish to be considered as a reply to my "Observations" on Sir Frederick Smith's and your Report on the Atmospheric Railway; and by the latter, requesting that, as my paper was addressed and of course presented to the Chairman of the Dublin and Kingstown Railway Company, I would consider yours of the 6th as addressed to me in my official capacity, and to be laid before the Chairman; adding, you have no doubt both he and I would see the propriety of giving the same publicity to both communications.

I need scarcely say, that I will most cheerfully comply with your wishes in this respect, and can safely answer for Mr. Low, that he will not have any objection. Before doing so, however, I think it expedient to wait for a further communication from you, in reference to mine of the 7th instant, which was a reply to yours of the 3rd, and also in respect to some observations I am now about to make on yours of the 6th instant, in which you say you cannot attempt to go over, step by step, the several objections I have raised, but that you will refer to the principal of them. And accordingly you do refer to *four* of my objections, viz. to my observations on steam-engine horse-power—to the waste space in the air-pump, and the force necessary to open the valves—to one of the calculations in my table 2,—and lastly, to my objections to your mode of separating constant from variable leakage.

As to the first of these, the horse-power, there is really no difference between us, except, as you say, matter of taste as to which of our modes of expression is most likely to convey a correct idea to the reader. On this subject there is one other remark I might have made in my former communication, but that I was desirous to avoid, as much as possible, lengthening that already too lengthened document.

In using Watt's unit of horse-power, you do not apply it to Watt's data, nor according to Watt's directions.

The formula of calculation which we call Watt's is founded in part on the fact, that the steam pressure on the piston is unknown, and his data are the measured pressure in the boiler, reduced by a certain arbitrary co-efficient, (supposed to represent the difference between this and the actual pressure on the piston,) is taken to represent the latter, and used in combination with the area and velocity of the piston.

You begin exactly at the other end, taking the known and measured pressure on the piston, and calculate as if this coincided with the empyrical pressure of Watt's formula. If these really did coincide, so should your results and his; but the simple fact that what he *estimated* at 33,000 lbs. is well *known* to be 55 or 56,000 lbs., or even more, is substantial proof of the absence of the assumed coincidence.

However, in going so fully as I did into the horse-power question, my object was not to differ about terms or modes of expression, but to prevent any mistake on the *money* part of the subject, or the amount of capital to be expended on engines, which it is very important should be rightly understood.

Your second objection is with respect to the waste-space in the air-pump, in regard of which you assume I was mistaken, not knowing that false bottoms of wood had been inserted with the view of filling up these spaces. My letter of the 7th will have set you right on this point, and shown you the misapprehension you labour under, in addition to which I have this morning, for the first time, seen a copy of a paper given to you by Mr. Samuda, pending the drawing up of your report, (almost certainly before the 27th January last,) which seems altogether to have escaped your recollection, and of which, lest you should have lost the original, I here give a transcript:—

Statement sent to Professor Barlow, previous to any of the correspondence.

"The space left at the top of the air-pump at the end of its stroke, consists of three quarters of an inch between the piston and the cover, and an annular space one inch wide and four and a half inches deep, round the wooden packing, which has been put on the piston for reducing its stroke. These two spaces (exclusive of the recesses of the valves) contain 1,345 cubic inches, which is 2-37ths of the whole pump."

The remainder of the paper is filled with calculations of the effect of this waste space on the power expended in working the pump, and is not necessary to be transcribed for the present purpose.

With respect to the present remark, that the weight of the valves was not taken into your account, and that if the merit of the invention rested upon so minute a point as this, the advantages of it would be of a very doubtful character. Now, with every possible respect, I am under the necessity of differing with you. In my paper I did not lay much stress on this point, because it could be so fully remedied in a properly constructed pump; but if you will recollect, that (as stated in the note, p. 47 of my MS.) the force to open these valves varies from 2.63 inches to 0.65 inches of mercury; or that, on a mean of eight experiments, it amounted to 1.263 inches of mercury, equivalent to 0.631 lbs. additional pressure over the whole area of the piston; and that at say 20 inches of exhaustion, the *whole mean* pressure on the piston was but 4.53 lbs., and that, consequently, this valve resistance amounted to no less than 14 per cent. of the whole power,—it cannot possibly, with any justice, be thrown out of consideration, when deducing from the wretched pump at Wormwood Scrubs, the probable performance of a properly and well-made air-pump.

Your third objection is thus stated:—"I am rather surprised that you did not suspect some error in your formula, or in your data, when you find, as in Table 2, page 16, that the force expended to support a vacuum of 23½ inches for the whole length of pipe requiring 42 strokes per minute, amounted to only 9.8 horses power. The engine at this time was certainly doing all it was capable of, viz.—the full force of 16 horses (of 52,000); so that, according to your result, two-fifths of the power of the engine you must have supposed to have been lost, which is rather a large deduction for profitless power; whereas our 26.2 horse power, (of 33,000) reduced according to our ratio, gives just 16 horse power, as it ought."

Before speaking of the formula of calculation, I must remark as to the latter part of your objection, that it is by no means an obvious inference, that the boiler which was capable of supplying steam of a certain density for 29½ double strokes per minute, the rate or velocity from which, at Report, page 7, you deduce the nominal horse power, is capable of supplying the same cylinder with steam of the same density for 42 double strokes per minute; and if such be not the fact, your inference as to profitless power necessarily falls to the ground. Indeed, it would be impossible to know whether or not the engine was doing all it was capable of, without first ascertaining the pressure of the steam in the boiler, which does not appear to have been done in this case.

As to the formula from which I calculated, Table 2, it is yours, not mine; as I have used that given by you in Report, page 7, namely, multiplying the area of the piston by the mean pressure, and this again by the velocity, dividing by 52,000, the divisor which, according to your desire, I have adopted. I here repeat the calculation, which I cannot see to be wrong:—

The correct mean pressure at 23.5 inches exhaustion is 2.93 lbs., therefore,

Area of Pist.	Mean Press.	Dble Strokes.	Length of Dble Str.
1104	× 2.93	× 42	× 3.75 *ft.*

$$\frac{1104 \times 2.93 \times 42 \times 3.75}{52{,}000} = 9.79 \text{ horse power.}$$

There remains but one other of your objections to be replied to,—that which you make to my other observation on your mode of separating constant from variable leakage. The result of your objection is, that your method, by counting the strokes of the air-pump, is sufficient. My objections were two-fold; first, to the *mode* of experimenting, and second, to the principle of calculation. With respect to the first, my objection is, that necessarily it adds the whole leakage of the air-pump piston to that of the travelling piston and long valve; by the leakage of the air-pump piston, I mean that quantity of air which passes from one side of the piston to the other, in consequence of bad packing, during the stroke, and with which of course the travelling piston and long valve has nothing whatever to do. Now from an indicator diagram at this moment before me, I find that in some strokes, (the wretched pump again!) the discharge valve does not open at all; of course no air is discharged; yet each such stroke would, by your method, be charged at its full value to the leakage account; therefore the mode of experimenting is wrong.

As to your principle of calculation, the number of strokes can only be the measure of leakage by virtue of the quantity of air taken out at each stroke, which of course can be computed. But in such computation, the ratio of exhaustion (r in my theorem) is an indispensable element. But what is this ratio?* It is the numerical relation of capacity between the receiver or main alone, and the same receiver and air-pump together; consequently, as the size or capacity of the receiver is varied, so also is this numerical relation; consequently, the quantity of air taken out at each stroke is different for each capacity of the receiver; consequently, the number of the strokes of the pump is not a measure of the exhausting power of the *same* air-pump for receivers of different capacities, unless the actual quantity of air taken out at each stroke be ascertained: and therefore the principle of calculation adopted by you and your colleague is objectionable.

In consequence of the severity of the weather, your letter, which ought in course to have arrived yesterday afternoon, did not reach me till late to-day; and as before complying with your wish of publishing your reply, I would be very anxious to hear from you in answer to this, as well as to mine of the 7th, I have put every thing else aside, so as to get this off by this night's post, the hour for which is now so close at hand, that I have not time even to read over what I have written, and must content myself with sending forward the rough draft.

Believe me, my dear sir, to be with the most sincere respect and regard,

Yours very faithfully,
T. F. Bergin.

P. S. I have just glanced over the editorial article in the Railway Times, and have no doubt you will entirely believe me, when I assure you I am no party to it, and that it had not only not my consent, but was without my knowledge.

This letter was put into the post-office in Dublin on the 9th January last; but I have since learned from Mr. Barlow that, in consequence of his absence from Woolwich, he did not see it until the 16th instant, when he proposed a visit to Acton (Wormwood Scrubbs), for the purpose of measuring the air-pump, to which I at once assented; but the following, received yesterday, renders such visit unnecessary, and closes this discussion:—

Dear Sir, *January* 21, 1843.

I find in your letter of the 9th instant an extract from a paper put into my hands by Mr. Pim, before we commenced our experiments, and which was afterwards returned to him, and of which if I took any copy it is lost or mislaid. This, however, gives the measurements I wanted, and it will not therefore be necessary to go to Acton to obtain them, as I had proposed to do.

These dimensions give 1,345 cubic inches of unoccupied space at the top of the pump (independent of the valve recesses), and which is stated to be 2-37ths of *the whole pump*. You appear to have added 449 inches for valve recesses, making the whole unoccupied space 1,794 inches, or 1.038 cubic feet. This agrees with what you have stated in your first note, where you say "the whole space within the pump, including valve recesses and clearance, as it is technically called, is 15.411 cubic feet;" whereas your whole investigation is founded on the supposition that the whole space of the pump is 16.449 cubic feet, and I find in page 13 of your MS. that you state the whole space of the pump to be 16.45 cubic feet, and that there is an unoccupied space of 1.0385 cubic feet both at top and bottom.* As I take it for granted now that the latter capacity is correctly stated, I am bound to say that this fully bears out the amount you have adopted, without admitting an error in the amount of blockage, as I had supposed. Moreover, I must add that the annular recess at the top of the piston was the only space to which my attention was called, as consequent on the shortening of the stroke; and that, amongst the mass of necessarily rough elements on which the whole inquiry rested, I did not think it necessary to introduce it into my investigation.

As it is not my intention to lengthen out this discussion, I shall make no remarks on any other part of your letter, except to assure you that I never for a moment imagined that you had any part, directly or indirectly, in the article you allude to. I shall continue to look forward with interest to the completion of your experiment, when something like satisfactory data may be obtained, and when we shall be no longer called upon to make extraordinary allowance for imperfections it is impossible correctly to estimate.

I am, dear Sir, yours truly,
Peter Barlow.

* The fluctuations of the gauge show that the results *cannot* be the same with an "indefinite atmosphere of the same density"

* Mr. Barlow seems under some misapprehension in this remark. The whole space within the covers of the air-pump is 16.449 feet; but of this, the piston space and *one* waste space only, or 15.411 cubic feet, is at any time in connection with the main, and on this latter quantity my investigations are founded, and not on the former, as Mr. Barlow seems to think.

NAVIGATION OF THE COLNE.

(Continued from page 11.)

It is not easy to account for the great indifference with which the inhabitants of Colchester receive every proposal for the improvement of the navigation of the Colne. It is the natural port of a vast extent of country, having a circumference of eighty miles, but from the present state of the river, a very small portion of the trade which the supply of such an extent of well-populated country must produce, comes into Colchester. That the river is capable of all those improvements which are necessary to make it a flourishing port is sufficiently evident from the remarks already made in tracing the history of the proposed improvements, but before we proceed to speak of Mr. Bruff's plans, it may be well to inquire into the state of the outfall, for if this be not sufficient, all else that may be done will become useless.

"The mouth of the Colne river, or outfall of the port of Colchester," says Mr. Bruff, "whether viewed as to its magnitude, security, depth of water, facility of access and departure, is scarcely equalled by any port on the eastern coast; and certainly there is no one so favourably situated from its proximity to the sea, and other causes, for carrying on a great trade."

This opinion is supported by Mr. Edwards, who says, "that considering the position and magnitude of the town, and the security and depth of the outfall of the Colne, the navigation of the port cannot but be considered in a most deplorable condition." Mr. Bruff's statement, however, is objected to by Mr. Tabor, who asserts that numerous shoals and banks exist in the estuary of the Colne, and that there is great danger in entering the channel from the north, and from London. This has induced Mr. Bruff to trace the condition of the navigation from the outfall of the river to Wivenhoe, and the detail is worthy of the careful consideration of all who are interested in the subject.

"To those gentlemen who are not conversant with the entrance of the Colne river, I will, in a few words, place before them its position and circumstances. Below Mersea Island the rivers Colne and Blackwater (the latter comprising the port of Maldon), converge, and empty themselves into the general estuary of the Thames, and about four miles from Mersea Stone the waters of both rivers unite, and form one common channel. Now I beg it to be distinctly observed, that such difficulties or impediments as really exist in the entrance of your river lie without this point of meeting, and therefore equally apply to the entrance of the Blackwater or Maldon river. But we never hear of impediments existing at the entrance of that river, even for vessels of five hundred tons and upwards, which occasionally frequent it. The entrance of both is undoubtedly affected by shoals, but not to an extent to impede the free ingress or egress of vessels of five hundred tons.

"The south channel to or from the Thames is approached by the West Swin, and is impeded by portions of the Gunfleet and Buxey sands, also by the Eagle and the Knoll. But this entrance is buoyed and well defined, and the least draught which has been found on the very shoalest point was nine feet at low-water spring-tides, and twenty-five at high water; at low-water neap tides there is about twelve feet water at the shoalest point. The soundings in the channel, however, at all other points up to Brightlingsea creek, range from two and a half to six fathoms at low-water spring-tides, and is completely sheltered from every wind.

"Approaching the port from the north, the entrance is by the Wallett channel, both for the Maldon and Colne rivers, the least water in which is over the Eagle flat, where three fathoms are found at low-water spring-tides. This entrance is by far the best, and has also the advantage of deep water, which is a peculiarly fortunate circumstance, considering that all the deep-laden vessels come from the north; as also such foreign trade as at present pertains to the port or will hereafter arise.

"Proceeding upwards with the navigation, there does not appear to be any obstruction of moment until past Wivenhoe, except the passage of the Hound shoal at the oyster layings, over which there is from fifteen to seventeen feet at high-water spring-tide, and from eleven to fourteen feet at high-water dead neap-tide, according as it is influenced by the state and direction of the wind. But, however much either the Hound shoal or oyster layings may be an obstruction to the navigation of the river, as at present conducted, it would, I believe, be found a very slight impediment to the passage of large vessels when the improvements which I have proposed from Wivenhoe upwards are carried into effect."

From this account it appears that there is no serious impediment to navigation at the mouth of the river, nor can any be expected which the science of the engineer is not amply sufficient to meet and remove. It is, therefore, only in the upper portion of the river that great improvements are required, and examining Mr. Bruff's proposal, upon the broad question of which plan would be most effective and beneficial, we can have no doubt in stating that it is the only one that has come under our notice worthy of serious attention as a permanent work. Vessels drawing fourteen feet and a half of water can now, at the top of the tide, come up the river as high as Wivenhoe, except a day or two before and after the dead of the neap tides, and by dredging and other modes, the channel upon this part of the river would be probably deepened. Mr. Bruff has therefore, judiciously, we think, turned his attention to the formation of a floating-dock, and for the construction of this he considers it necessary to cut a ship-canal, opening into the present channel a little above Wivenhoe. Upon this part of his plan we do not intend at present to make any remarks, as it is a subject which would require more space for full consideration than in this number can be allowed. We shall, therefore, only give a brief description of the works he proposes, so as to put our readers into possession of the present state of the question, and to enable them to judge of the application of all the several plans by which it has been proposed to improve the navigation of the Colne.

Mr. Bruff proposes in the first place to excavate a floating basin in the low grounds near Wivenhoe, to be entered from the river by a ship lock. This basin is intended for those vessels not requiring to go up to Colchester, and would be of such an extent as to accommodate thirty square-rigged vessels. From the basin, vessels would be towed to the floating dock at the Hythe, a ship canal uniting the two, which canal would be 70 feet wide at the water-line, and 15 feet 6 inches deep. The floating dock would have an area of eleven acres, and be capable of containing from thirty to forty thousand tons of shipping, surrounded by a quay one hundred feet wide. The ship-lock at Wivenhoe would be, according to Mr. Bruff's drawings, 150 feet long from sill to sill, and 45 feet at the high-water line. The chambers and wings would be of brickwork, with an inverted arch, and stone quoins and coping. The cost of the works, exclusive of land, is estimated at £56,000.

At a time when great improvements are being made, or are projected, in almost all the important ports of the country, it is scarcely to

be imagined that the navigation of the Colne can be long allowed to remain in its present state. It is a work of great local importance, but it is also of national interest. We are not anxious to force any one plan in particular upon the attention of the commissioners, if they will but adopt one that offers a reasonable expectation of affording the accommodation indisputably required by the shipping interests, which are greatly suffering, whether they perceive it or not, from the timid policy of the commissioners. There has been enough of delay and indecision, it is now high time that something should be done. In any well-designed project we will give them all the assistance in our power, but we will as zealously attempt to prevent the continuation of the temporizing policy that has hitherto characterized all their proceedings.

PROPOSED PLAN FOR CONVERTING SUNDERLAND HARBOUR INTO A FLOATING DOCK.

In our last Number, the proposed plan for converting Sunderland Harbour into a floating dock was briefly mentioned, but it is a work of so much importance and value, that we feel called upon to state the object and intended mode of operation as fully as we can with our present limited amount of information.

Considering the great commercial importance of Sunderland, and its entire dependence upon the port, it must be evident that whatever can contribute to improve the navigation, and render it more safe for shipping, is a benefit to every individual in that populous district, and of almost equal national value. Sunderland is considered the fourth port in the kingdom, but the harbour is notoriously unsafe from the heavy surf which rolls into it, and the frequent damage done to loaded vessels when lying upon the ground—damage which is estimated at from one to two per cent. per annum upon the entire shipping capital of the port. A greater depth of water is imperatively called for, and more especially as the average burden of vessels belonging to the port has been during the last few years increased from twelve to eighteen keels. The calamitous effects which followed the breaking up of the ice two years since, are well known, and show the necessity of some improvements for the better protection of shipping. But if the whole truth must be told, unless the Sunderland Harbour be made more safe for shipping, Hartlepool and the Tyne will take so much of its trade as to seriously interfere with its interests. The commissioners of the Wear, who have been most active in deepening the river, and rebuilding the piers, have therefore deserved the highest commendation for the efficient improvements they have projected under the direction of Mr. Murray, their Engineer, and for the performance of which they will probably have the authority of Parliament during the ensuing session.

The proposed improvement is, to convert the lower part of the tidal harbour into a floating dock by a wall of masonry, with a waste wear and flood gates, and piers, with navigable gates between them, across the river. The navigable openings will be 80 feet wide, and contain sluices or slackers for letting off the water as required. These gates are intended to be kept open from half-flood to half-ebb, at which time, during the springs, the water will be 7 feet above the present low-water mark. For the accommodation of the vessels which take the harbour at low water, when the gates are closed, it is proposed to form another opening 60 feet wide into a tidal dock, from which they will pass through another opening into the floating dock.

The expense of these works is estimated at £60,000, which it is proposed to borrow at interest, and a tax of 1½*d.* per ton per voyage will be imposed upon shipping, which will be an additional charge of about ¾*d.* per ton. Out of the income derived from the tax, it is intended to reserve £4000 a year for the reduction of the debt, and it is anticipated that the dock will ultimately be of little expense to the port beyond the cost of working.

The advantages to the navigation of the Wear by the execution of this plan, will be many. Whether any improvement of the outfall will be required, we are from the plan unable to determine, but it must be evident that an available scouring power will be obtained, which will not only deepen the channel, but also lower the bar at the mouth of the river. At present we have not the means of forming any opinion upon the detailed and particular application of the plan to the circumstances of the Wear, but from our general recollection of the harbour, and the acknowledged scientific attainments and practical experience of Mr. Murray, we have little doubt that Sunderland will, by its execution, have the advantage of an improved navigation as well as of a floating dock.

METROPOLITAN SEWERAGE AND THE POOR-LAW COMMISSIONERS.

Our attention has been drawn to the state of the Metropolitan Sewerage by an interesting and masterly address delivered to the Court of Sewers for Westminster, by Mr. Donaldson its Chairman, in which he completely exposes the ignorance of Mr. Chadwick and the Poor Law Commissioners upon questions of engineering practice, and endeavours to illustrate the necessity of a man's learning before he pretends to teach. We fully appreciate the value of the Report on the Sanitary Condition of the Labouring Population of Great Britain, although we have no love for the principles which actuate the Poor Law Commissioners, whose meddling interference and heartlessness have drawn upon them the merited contempt and antipathy of every man in whose heart there remains one pulse of benevolent feeling. That they have loaded with suffering a larger number of our distressed countrymen than have ever been benefited by the best and most enlightened measure of legislative wisdom, is not to be doubted—that they have by their rigorous construction and enforcement of the law done much to sap the very foundations of English habits—that they have attempted to blight in its bud the fruit of benevolence and charity, and have entailed upon the present generation the anger of Him who heareth the poor when they cry, need not be stated, for all men know it, deploring alike the present and anticipated consequences upon the nation at large. Such men, it might have been supposed, were the least likely to render a valuable report upon the sanitary condition of the labouring population. The selection of them, however, for such a duty, was in every respect judicious, and has justified the anticipation that might have been fairly indulged. The object of their commission is, to relieve the paying classes, and, in their legitimate capacity, they can only do this by oppressing the poor, but, in their new capacity of reporters on the sanitary condition of the labouring population, they must seek to accomplish the same object by improving those external circumstances which may affect health, and thus diminishing the probability of a burdensome pauperism. They have taken to this inquiry the same penurious, overbearing spirit exhibited in all their official doings—the same determination to sacrifice poverty, to render misfortune and dependence disgraceful, and above all to support their own falling power, and extend their influence. But in this instance it so happens that all these objects are to be accomplished by improving the condition of the out-door poor. The work-houses under their jurisdiction will soon be

emptied, because it is as well to starve out of them as in them—it is as well to die in the forest, breathing the breezes of heaven, unseen and untaunted by the menials who are employed to afflict poverty, as to drag out a miserable half-fed existence, in a state of bondage which true benevolence would scarcely inflict upon criminality and guilt. The craft is in danger, and the Commissioners themselves will soon stand in need of some new mode of subsistence; and having driven the poor from their houses of refuge, who so fit to form the plans for their sanitary condition when out of them? We again acknowledge that we detest their trade not less, but more, than that of a thief-taker, but as the latter benefits society by the apprehension of a rogue, and so prevents the accomplishment of a designed but not executed villainy, so they by their Report, should it be acted upon, may prevent them and others from inflicting an incalculable amount of bodily and mental suffering upon some of our distressed fellow-countrymen.

This is all the praise we can give to the Poor Law Commissioners, and that we have not mis-stated their principal, that is, their selfish object, will be quite evident from the manner in which they have attempted to inculpate the Metropolitan Commissions of Sewers. If they could but once obtain the control of the metropolitan sewerage, their principal object would be secured, and their official existence be prolonged. But, unfortunately for that object, they have overshot their mark, and shown their want of skill; they have pulled up the curtain before they were dressed, and shown their deformity. These would-be surveyors, engineers, or superintendents of sewers, attempted to teach before they had learned their own lessons, and have for their future edification been well flogged. But as we have little space in our present number to devote to the subject, and hope to publish in our next a letter from a correspondent in which the whole question of national sewerage is fully discussed, we must at once proceed to the subject immediately before us, which is the metropolitan sewerage in general, and that of Westminster and part of Middlesex in particular:—

"Since first I had the honour of being a member of this commission," says Mr. Donaldson, "now a period of twenty-six years, a more painful duty has never arisen than that of calling your attention to one of the most unqualified and unjustifiable attacks, which could ever have been penned against this Court, in common with other Metropolitan Commissions of Sewers, and to some specific charges in reference to this Court, contained in a report from the Poor Law Commissioners on an inquiry into the sanitary condition of the labouring population of Great Britain, presented to both Houses of Parliament by command of Her Majesty, July, 1842.

"It is far from my purpose to lead you through the wild labyrinth of subjects into which the writer of this report has thought proper to diverge. But I cannot forbear, in the first place, calling your attention to this remarkable feature, that whereas the inquiries of the Poor Law Commissioners are by their instructions confined to the other parts of England, Wales, and Scotland, they having already reported upon the metropolis, they have chosen to devote the greater part of their report to the metropolis, with the obvious intention of lowering, in the public estimation, all the existing institutions connected with the administration of London.

"It might have been thought that the mis-statements contained in the former Reports of the Poor Law Commissioners, and which had been fully exposed and contradicted by the report of your surveyors, would have led the Commissioners in their present inquiry to have proceeded with greater caution in the statement of supposed facts, and in the formation of their opinions. But the compiler of this report seems equally to have disregarded all proprieties."

Mr. Donaldson is no doubt right in supposing that the main object of the Commissioners was to find subjects of reproach against the metropolitan boards. But he had formed a very incorrect idea of the Poor Law Commissioners, if ever he imagined that their being detected in misrepresentation, ignorance, and imposture would teach them to be more careful of the characters of public bodies, or more cautious in their statements. Their objects can only be accomplished by perfect indifference to all those considerations which act upon generous and honourable minds. Their pretensions are unbounded—there is no subject upon which they are not able to pass a judicial opinion, from the quality of poor-house soup to the construction of a sewer. Upon the former they are undoubtedly well qualified to give a judgment, but that they are contemptibly ignorant of the latter, Mr. Donaldson has proved to even their satisfaction, if they were only well paid to report upon their own ignorance.

"The sewerage of the metropolis, though it is a frequent subject of boast," says Mr. Chadwick, "to those who have not examined its operations or effects, will be found to be a vast monument of defective administration, of lavish expenditure, and extremely defective execution. The general defect of these works is, that they are so constructed as to accumulate deposits within them; that the accumulations remain for years, and are at last only removed at a great expense, and in an offensive manner, by hand labour and cartage."

We have for many years, though entirely unconnected with any court of sewers, been practically acquainted with the sewerage of the metropolis, and unhesitatingly deny the sweeping imputation contained in this malicious paragraph. In the rapid extension of population in the suburbs it would not be difficult, we admit, to find instances of defective sewerage, and that in some parts the sewers are defective in construction must be allowed, but if there be one arrangement for the health of this crowded metropolis better than another, it is the sewerage. The main lines of sewers are for the most part ample in size and perfect in construction. But in opposition to Mr. Chadwick's opinion, which upon such a question is literally valueless, we will oppose that of Mr. Donaldson, an architect of great experience and taste, a man of unimpeachable integrity, who has been twenty-six years a member of the court of sewers for Westminster, and for eight years its chairman.

"During the present century," says Mr. Donaldson, "and particularly since the removal of Old London Bridge, every opportunity has been taken to lower the outlets. For instance, the Essex-street sewer, between 1816 and 1836, has been lowered from its outfall at the Thames to near Great Russell-street, Bloomsbury, in length 5,800 feet. The eastern branch of the Hartshorn-lane sewer, between 1831 and 1839, from Long Acre to the New Road, by the line of Tottenham-court Road, in length 4,200 feet. Another branch of the Hartshorn-lane sewer, between 1820 and 1837, from the south end of the Haymarket to Oxford-street, by the line of Princess-street, Wardour-street, &c., in length 3,400 feet. The whole of the King-street sewer, between 1830 and 1832, from Westminster Bridge to St. James's Park, 1200 feet. The Wood-street sewer, between 1824 and 1832, and the Romney Row or Horseferry-road sewer in 1840, have been lowered and rebuilt of enlarged dimensions from their outlets for their whole extent, being a length of 6,850 feet, presenting in these lines alone a total of *only* 21,450 feet.

"I may also remind you of the considerable works executed at Chelsea since I have had the honour of being your chairman—that is, within the last eight years; during which we have constructed, in that district alone, from the river Thames, 11,000 feet of new sewers.

"But the greatest work ever executed by this or any other Commission has been effected on the King's Scholars' Pond sewer, which has been wholly rebuilt for an extent of upwards of three miles from the river side to the Regent's Park, within the last twenty-four years. And here I cannot but express my wonder that one, who—as the compiler of this Report—affects to investigate every point regarding the drainage of this metropolis, should not have taken the trouble himself to examine the works of this commission."

Mr. Chadwick sneers, in his ignorance of practical subjects, at the size of King's Scholar's Pond Sewer, which is in some parts eight feet six inches wide, and eight feet high; and after comparing it with the cloacæ of Rome, utters his terrible denunciation—"all this, however, appears to have been mistaken in principle, and in ignorance of the mischiefs of the generation of gases, and of the principles of hydraulics, and their application for the attainment of the objects in question." Men of science and practical skill, who have earned for themselves,

under the guidance of high moral principle, the respect and approbation of their profession as well as of the public, have studied the subject for the last half century, but their science and skill were imaginary, and the praise should have been discredit,—it required the pneumatics and hydraulics of a Chadwick to make a sewer. That the Westminster Commissioners have not been inactive nor indifferent to the public interests, to the extent of their *limited* knowledge and experience, Mr. Chadwick will not deny, but still they are ignorant and incapable, their officers are inefficient, and their sewers are bad in construction. Let us examine for a moment one of the objections raised by this veritable reporter.

"A large proportion of the most expensive sewers," says Mr. Chadwick, "are constructed with flat bottoms. In proportion as the water is spread the flow is impeded, and the deposit of matter it may hold in suspension increased. *Mr. Roe, civil engineer, who, much to the honour of the Holborn and Finsbury District of Sewers, has been appointed to the care of their sewers, and is, perhaps, the* ONLY *officer having the experience and qualification of a civil engineer*, states that, as compared with sewers or drains with bottoms of a semicircular form, those with flat bottoms invariably occasion a large amount of deposit; and with the same flow of water, the difference of construction occasions a difference of more than one half in the deposit which is left." And this is the *new* construction which Mr. Chadwick would palm upon the world as the great improvement which he is to be the honoured individual to introduce for the public benefit, and which Mr. Roe, the *only* officer having the experience and qualification of a civil engineer, recommends so highly. That Metropolitan sewers were once upon a time, before the world had an expectation of being honoured with the presence of either Mr. Chadwick, or Mr. Roe, built with straight bottoms, every body knows, but Mr. Donaldson informs us, that for the last *fifty years*, there has not been a sewer constructed by the court of which he is chairman, that has not had "a segmental, or inverted-arch bottom, the depth equalling one-sixth of the chord-line. We have about 134 miles of arched or covered sewers, varying in size from two feet six inches in width, to twelve feet wide. Of this length, 93 miles, or two-thirds, have *curved* bottoms. The remainder are of old construction, and with flat bottoms, which are either rebuilt from time to time, as occasion may require, or a new invert inserted, varying from a segment to a semi-circle." Who now will trust Mr. Chadwick's Report, when he pretends to dictate upon subjects of construction. But we have one other of his statements to consider, or rather we will leave Mr. Donaldson to answer him.

Much may be said upon the question whether sewers should be built with straight or curved sides, but whatever may be the opinion of a practical scientific man upon the subject, he will treat the arguments of those who differ from him with respect and attention. Not so with Mr. Chadwick: "By being built with flat sides," he says, "instead of with curved sides, *which give the strength of an arch*, they are apt in clayey and slippery ground to be forced in. The expense of the improved form is nearly one-fourth less than those in common use." Now it is a singular fact, that in the six sections for sewers, given by Captain Vetch, of the Royal Engineers, and published in the Appendix to Mr. Chadwick's Report, there is not one with curvilinear sides. As to the curvilinear side giving the strength of the arch, and preventing the sewer from being forced in, it is one of Mr. Chadwick's new discoveries, and as such, will be justly valued. In the Westminster Commission, where upright (*flat*) sides are used, there has not occurred a single instance of a side wall being forced inwards. It may well be asked:—Can this be said for the curvilinear form?

"We are to recollect," says Mr. Donaldson, "that under-ground constructions must be built so as to last for ages, otherwise a continued rebuilding of sewers causes a constant breaking up of the streets, an obstruction of thoroughfares, and a suspension to a certain degree of the commerce of the tradespeople on the line. The sewers must be large enough not merely for the ordinary service of relieving soil drainage, but also for the carrying off the torrents of water, which fall during violent storms. Hence a large capacity must be given them. Again, this large dimension is not without a further use in enabling the officers and workmen to inspect and repair them with sufficient facility, the width even of our second sewers enabling two workmen to pass each other. As regards the upright sides of the sewer, it must be borne in mind that all circular work, constructed of brick, can only be formed by making the joints more open at the extrados than at the intrados, for the square shape of the brick does not lend itself to other than rectangular construction. Now these open joints are filled with mortar in a moist state, and before it is set, the earth to the depth of several feet is filled in, the centres are struck, and the consequence is an irregular settlement of the whole work; whereas with spreading footings, an invert at bottom, a circular arch at top, and upright side walls, most of these inconveniences are avoided, and the sewer, even if the earth be washed away, at the top or sides, as sometimes happens from the bursting of one of the large main water-pipes of the water companies, stands upright and alone on its broad base, whereas the oval sewer must have inevitably fallen over. I may also add two other important reasons for giving as much square construction as possible to the body of the sewer, and these are, greater security against imperfect workmanship and detection of false thicknesses of work at sides. One of the assistant engineers of the Great Western Railway Company was allowed to construct a sewer over the main line of the Ranelagh, of a somewhat similar form to that which it is attempted to force us to adopt: it failed; and being rebuilt of the usual section of this Court, has stood ever since.

It appears that the sewer recently built between Battle Bridge and the new Model Prison of the egg section, has still its struts left inside, its form not being such as to enable it to withstand the unequal pressure of the ground. The main line of the Fleet sewer from Battle Bridge to Camden town is a very close approximation to the Westminster sewers' section, but with this difference, that it has no footing, a want which renders it less substantial to support the side walls, and, in case of the arched bottom being washed out, causing them to be very insecure. Besides, in the event of its being judged expedient to increase the depth of a sewer by putting in a new bottom by underpinning, this operation becomes comparatively easy with upright side walls—almost impracticable when they are curved. Much stress is laid in the Report upon the curved side walls, as naturally aiding the rapidity of the current, but in fact the ordinary sewerage rarely rises above the invert, and when it does there is such a force in the volume of water, that no perceptible obstruction is offered by the absence of the complete circular form.

Having sufficiently exhibited the utter worthlessness of Mr. Chadwick's Report in all those parts where he pretends to dictate upon questions of practice, which can only be known to the surveyor, and to those persons who have had the management of the sewerage of large cities, we cannot close these remarks without an expression of regret, that he should, from a foolish attempt to bring the sewerage of the Metropolis under the management of the Poor Law Commission, have exposed himself to the strong censures we have been compelled to pass upon him. There is nothing in his Report peculiarly new, no principle is developed which has not been long known to the profession, but with the powers given to him, and the facilities he possessed from his connection with the Poor Law Commission, he has been able to collect some new and important illustrations. The publication of these by the government at a cheap rate, will inform the public upon the subject, and draw attention to many questions intimately connected with the national weal. From this cause it is the more to be regretted, that there should have been any necessity for such an exposure of errors and mis-statements as we have been compelled to make. In the necessity of the adoption of some measures to secure a national sewerage, all men agree in opinion, and some alterations may be desirable in the Metropolitan system, but not those suggested by Mr. Chadwick.

REVIEWS.

Ensamples of Railway Making. 8vo. London, 1843, Weale.

THIS is not only a valuable addition to the library of an engineer, but is, perhaps, the cheapest professional work ever published. It chiefly consists of an account of the mechanical works on the Utica and Syracuse Railroad, and of the railways of Belgium. The former appears to be from the pen of Mr. Weale, assisted by Mr. Isherwood, of New York, and contains much interesting and valuable information. The preliminary observations are written in a style not altogether satisfactory, for they are wanting in that clear, concise expression so necessary in all works upon scientific and professional subjects. The article on the railways of Belgium is translated and compiled from official documents by Mr. Edward Dobson, who is described by Mr. Weale as "an enterprising and talented young engineer, who has qualified himself for employment in this particular branch of his profession, and gratuitously bestowed much of his time in bringing before the public useful and valuable information on this subject, together with some comparative estimates of the cost of railway construction in this and other countries, which I have inserted in the second chapter of preliminary observations." Mr. Weale has, we think, injudiciously taken the editorship, if not the authorship of this volume, for, with all possible respect for him personally, and entertaining the highest opinion of his knowledge of professional books, it is scarcely possible that he can, although in constant communication with professional men, be so practically acquainted with engineering subjects, as those for whom all such works are necessarily written. These remarks are made in a friendly spirit, and express, we are sure, the general opinion of professional readers, and they will be rather confirmed than removed by the volume before us. Even in the laudatory observations we have quoted, there may be perceived a want of skill in expression, an ignorance of style, which causes the reader to stumble. The first paragraph in the preliminary observations is an illustration of the fault of which we complain.

"It is the object of this publication," says Mr. Weale, "to introduce to the notice of professional engineers, and to the commercial and trading classes, the leading principles of a system of railway construction, which, —more especially so far as the first portion of the volume extends,—has not been practised in Great Britain or Ireland, or as yet been sufficiently explained, to lead to its adoption by those most interested in the subject."

This passage gives the reader an indistinct perception of the author's meaning, and it must be read two or three times before it is actually understood. But we turn willingly from the consideration of the style, to the more pleasing task of following the author through some of the subjects he has introduced to his readers.

The first part of the volume contains, as already stated, a description of the works upon the Utica and Syracuse Railroad. These works are of the cheapest possible construction, and might be adopted, in the opinion of the author, with great advantage in Ireland. That something must be shortly done for that distressed country is evident, and its poverty, as well as our experience, proves, beyond all doubt, that the expensive systems introduced in England cannot be allowed in the sister-island. The account which is here given of the American railroad is, therefore, extremely valuable, and suggests many constructions which are precisely adapted to the condition of Ireland.

"The Utica and Syracuse railroad is a continuation of the Utica and Schenectady railroad, and forms a part of the great line of railroad communication between Albany and Buffalo. Commencing at Utica, on the river Mowhawk, this railroad passes in a north-westerly direction along the upper valley of the Mowhawk, until it enters Rome; on leaving Rome, its further course is at first to the south-west, in which direction it crosses the Oneida Creek, one of the principal feeders of Lake Oneida. It afterwards inclines to the west, and, passing through the villages of Canistota, Sullivan, and Chittenango, in Madison county, and Fayetteville and Orville in Onondoga county, terminates at Syracuse. Throughout its entire course, this railroad runs nearly parallel with the line of the Erie canal, which it crosses twice, first on entering Rome, and again on leaving that place. Its length is 52·71 miles, of which distance, piles were driven 19·26 miles, using about 800,000 lineal feet of pile timber, and 33·45 miles were graded by excavations and embankments in the summer of 1836. The superstructure was laid in the spring of 1837, and the road was finished in July of the same year, at a cost of 941,475 dollars (£196,140 12*s.* 4*d.*): it forms one link in the great chain extending from Boston, on the Atlantic Ocean, to the inland lakes that separate the United States from Canada. It presented no great obstacles for the skill of the engineer to surmount; still, much that is curious in science and valuable in practice may be found embodied in the description of the bridges and other works pertaining to it."

This railroad has now been opened, and in constant use for five years, and has, to a certain extent, proved that safe and permanent railroad constructions can be formed for a small and remunerating expenditure. There can be no doubt, that instead of costly viaducts timber bridges might be introduced, and other great savings in construction might be safely adopted; but at the same time it must be remembered, that all public works should be designed upon a scale suited to the condition of the country, and the habits and feelings of the people. The Utica and Syracuse Railroad would be no better suited to the taste of the English population than the life of the back-woodsman; and such is the state of feeling in this country, that a shareholder in any of our public companies would rather forgive a director for not declaring a dividend, than for an apparently ill-designed construction upon a public work, in the character of which he feels that his own is in some degree implicated. In a country which has risen to the highest station of commercial enterprise and glory, which has a capital that would supply manufactured goods for the whole world—and such is the present condition of England—temporary erections cannot be introduced; its public structures must be proportioned to its condition. America and Ireland are poor and depressed, and for their conditions another kind of structure is required. Their states are essentially different, inasmuch as one has a certain degree of credit in the money market, and the other has none—but both have to gain prosperity, and with that will come the desire for a more permanent kind of national structures. But to gain this prosperity an easy and rapid transit is required, for it combines the operations of the industrious,—which is one of the principal elements of success. The adoption of a cheap mode of railway formation in Ireland is, therefore, a question of serious and momentous importance, and Mr. Weale has done a public service, and will receive the thanks of all who are interested in the fate of that depressed and suffering country, by the publication of this volume.

"To carry the subject of our inquiry a little further," says Mr. Weale, "it may not be considered tedious to remark, that the Utica and Syracuse railroad affords one instance out of many in the United States of America, in which a railway to be worked by locomotive power has been constructed and appointed at an average cost per mile of £3600.

"This amount is exceedingly small, when compared with the cost of the railways of other countries. The average cost per mile of the railways in Great Britain and Ireland, has been about £30,000; of the Belgian, £15,000; and of the Prussian railways about £9000 per mile; the latter being, however, generally laid with only a single track.

"The Irish Railway Commissioners, assuming the average cost per mile of the railways proposed by them to be from £8000 to £12,000, estimate the probable return from the capital to be expended at the rate of 3½ per cent. only.

"Now, without entering upon the question whether these lines are the best that could be adopted, or how far they are superior to the lines previously surveyed for private companies by Messrs. Nimmo, Telford, Bald, and Stephenson, and which were estimated by those gentlemen to yield a profit of from 10 to 13 per cent., let us examine whether it is not practicable, by strict attention to economy, and by following out the principles of the American engineers, to construct in Ireland, and in the

remote districts of England and Wales, single lines of railway, suitable for the passage of locomotives at a moderate speed, at an expense of from £4000 to £5000 per mile, and which should, even at the low ratio of traffic assumed by the commissioners, yield a profit of from 8 to 10 per cent. on the outlay.

This Mr. Weale endeavours to prove could be done, and adduces much important information as evidence in favour of his plea; and that he is upon the average of lines right in his calculation, we are convinced from our own examination of the subject, conducted with a similar view of introducing a cheap railway system into Ireland. Here we must for the present leave that portion of the "Ensamples" which relates to the Utica Railroad, with the remark, that the student will find in the plates and descriptive letter-press a store of valuable information upon construction, and the engineer himself will, from the details, derive some hints that he may render available in practice.

The Belgian railroads are in many respects peculiarly interesting to the English engineer, and the profession is already in possession of much information concerning them. But the memoir contributed by Mr. Dobson to this work, compiled from official documents, is a useful addition to our libraries; and founded, as it seems to be, upon the last Report of the Minister of Public Works, may be expected to contain all the information that can at present be obtained.

To every man interested in the establishment, construction, or working of railways, we earnestly recommend a perusal of Mr. Weale's "Ensamples."

The British History of Geoffrey of Monmouth, in Twelve Books. Translated from the Latin by A. Thompson, Esq. Revised and corrected by J. A. Giles, LL.D. London, 8vo. 1842.

This volume is one of a series of the Monkish Chronicles now in the course of publication. Bede's Ecclesiastical History, Gildas and Nennius, Richard of Devizes, and Richard of Cirencester, have already appeared. The most important of the other ancient Chronicles are preparing for publication. By these invaluable reprints, Mr. James Bohn has merited not only the thanks but the encouragement of every man who feels the slightest interest in the records of his country, and in every historical library they must find a place. The work before us has been carefully revised and corrected from MSS. by Dr. Giles, whose known acquirements admirably suit him for such a work. The introduction, however, is meagre, and nor such as we hoped to have seen prefixed to such an edition of Geoffrey of Monmouth. In every other respect we are justified in speaking of the edition with the highest praise.

To all our readers, and to our architectural friends in particular—whose pursuits demand an extensive acquaintance with historical works—we recommend this volume, and, judging of the other publications by this, the entire series. There have been authors who have warmly defended the assertion of Geoffrey, that it is a translation of an ancient British manuscript. If this could be admitted, it would not, perhaps, be more valuable as a fable of that early period, than it is as one of the reign of Henry the Second. For its real age, however, we must look into the work itself, for it is only to be ascertained by internal evidence. The only pretended history of the Chronicle is that furnished by Geoffrey himself.

"Whilst occupied," he says, "on many and various studies, I happened to light upon the history of the kings of Britain, and wondered that in the account which Gildas and Bede in their elegant treatises had given of them, I found nothing said of those kings who lived here before the Incarnation of Christ, nor of Arthur, and many others who succeeded after the incarnation, though their actions both deserved immortal praise, and were also celebrated by many people in a pleasant manner, and by heart, as if they had been written. Whilst I was intent upon these and such like thoughts, Walter, Archdeacon of Oxford, a man of great eloquence, and learned in foreign history, offered me a very ancient book in the British tongue, which, in a continued regular story and elegant style, related the actions of them all, from Brutus, the first king of the Britons, down to Cadwallader, the son of Cadwallo. At his request, therefore, though I had not made fine language my study, by collecting florid expressions from other authors, yet, contented with my homely style, I undertook the translation of that book into Latin. For if I had swelled the pages with rhetorical flourishes, I must have tired my readers by complying their attention more upon my words than upon the history. To you, therefore, Robert, Earl of Gloucester, this work humbly sues for the favor of being so corrected by your advice, that it may not be thought to be the poor offspring of Geoffrey of Monmouth; but, when polished by your refined wit and judgment, the production of him who had Henry, the glorious king of England, for his father, and whom we see an accomplished scholar and philosopher, as well as a brave soldier and expert commander, so that Britain with joy acknowledges that in you she possesses another Henry."

A correspondent, who is well qualified by his intimate acquaintance with the literature of the middle ages, is preparing a series of essays, which will shortly appear in this Journal, on the Monkish Chronicles, and the illustrations they offer to architectural history. Any remarks upon the internal evidence as to the age of the Chronicle or the history it contains is, therefore, quite unnecessary, and we have only the pleasing duty of recommending this edition to our readers.

A Descriptive and Historical Account of the Churches of the Division of Holland, in the county of Lincoln, with Illustrations from original drawings. By Stephen Lewin, Architect, No. 12. 8vo., Boston.

If we may judge of this work from the Number before us, and it is the only one we have seen, we may speak of it as an exceedingly creditable production. It is much to be desired that our architectural friends in the country would follow this excellent example, and give us drawings and descriptions of the churches in their neighbourhoods. If in addition to the perspective views they would furnish a few details of the most remarkable objects, the value of their exertions would be greatly increased. Perspective views of the fine old churches of England are not without a practical use, but every one knows how much more valuable they would be with an accurate ground plan and a few characteristic details. This suggestion is worthy of Mr. Lewin's consideration, as it would raise his contribution to ecclesiastical topography and architecture to a class very far above that in which it must now rank.

ARCHITECTURAL COMPETITORS.

We have seen advertisements in the daily papers, inviting competition drawings for a workhouse and a lunatic asylum. Many of our friends will, it is to be feared, avail themselves of the *chance* of obtaining employment, and be induced to send designs. It is sincerely to be hoped they may have fair play, but we are determined to keep a strict watch upon the proceedings, and should any of the competitors furnish us with evidence to the contrary, with their names, they may depend upon our zeal in using every means to expose the parties who are guilty of unfairness.

REPORT ON THE PRESENT STATE OF THE NORMAN TOWER (COMMONLY CALLED ST. JAMES'S TOWER), BURY ST. EDMUND'S, SUFFOLK.

BY L. N. COTTINGHAM, ESQ., ARCHITECT.

(*Concluded from page* 23.)

Western Front. The western front of the tower is a unique specimen of Norman architecture; from the ground floor upwards, the whole building is faced with stone. The unity of the design, also, greatly enhances its value: it is elevated to four stories. The first contains the entrance gateway, which consists of a projecting stone porch; it has three shafts on each side, in square recesses, with bases and capitals supporting a plain impost, above which a series of plain cable mouldings form the arch, which is covered with a stone penthouse roof, having a twisted cable barge moulding to defend the scale ornament which adorns the gable over the arch: it is supported on each side by a delicately panelled turret, which terminates with a pyramidical stone roof rising a little above the first string course. The jaumbs of the doors are composed of three slender cluster columns, with plain bases, carved capitals, and moulded imposts; the capitals have, undoubtedly, a conventional meaning—that on the south side represents two lions splitting the jaws of a dragon; the north side capital represents a naked human figure seated between two dragons. The arch above the caps is composed of a semi-cable moulding on each side, with a plain soffit. There was originally a very flat second arch, with the jaumbs and soffit inserted for the doors to shut against; this was probably richly carved with appropriate devices. The second, third, and fourth stories are flanked with small projecting buttresses, enriched between with semicircular arches, supported by small columns in alto-relievo; there are eight windows in this front, and a number of circular and semicircular moulded borders, forming panels, which are enriched with a kind of reticulatum, or network, formed by cutting the stones in a diagonal direction, into a series of meshes and other devices, giving it the appearance of Mosaic. The columns of the third story rest upon the backs of lions and chimeras just above the nebule string. The four eyelet windows up the staircase at the north-west angle, are pointed, the heads are each cut out of a solid stone. The embattled coping on the top of the tower has every appearance of being the original finish; if so, it gives additional value to the work, as it is perhaps the earliest specimen of embrasure work in existence.

There are some severe cracks and fissures in the masonry of this front; the arches, weatherstring-course, and battlements between the buttresses over the upper tier of windows, are in a very dangerous state, being so crippled, bulged, and sunk, as to render it necessary to take down and rebuild this part of the work. The whole of the compo stopping should be raked out where the ashlar is cracked and drawn off its bond, and fresh stones inserted inside and out; all the chinks and fissures in the rubble core of the wall must be grouted up solid, as the repairs of the ashlar proceed. The bas-reliefs taken out of the turret panels on each side of the entrance archway, formed no part of the original design.

South Side. The foundation of the north side of the south-front wall of the tower has been laid open, and an original postern doorway discovered near the centre of the wall. Westward of this doorway, there is a fracture in the masonry commencing at the foundations, which goes entirely through the wall from top to bottom, increasing stage by stage up to the bell-chamber story, under which the disruptions of the wall in various directions, are quite terrific. I am of opinion that these alarming fissures have been caused by the vigorous ringing of the bells, and somewhat accelerated by digging the cellars of a modern house close to the walls below the foundation of the south-west angle of the tower. The brick walls of the vaults abutting against the walls of the tower should be removed, and the angle of the tower wall carefully underpinned, with a spreading footing in solid masonry; the weather table, parapet-wall, and coping, on this side, are in such a shattered and bulged state, that it will be necessary to take it down and rebuild it in solid masonry; a considerable portion of the parapet wall all around the tower inside, is built of brick, and some portions of the Norman decorations on this side of the tower are repaired in the same material, which has a very unsightly appearance. All the modern compo stoppings should be carefully raked out, the broken ashlar stones restored, and the fissures in the rubble core grouted up solid: some of the arch stones must be reinstated, and the panels, columns, and mouldings repaired. A considerable portion of the lower part of this side of the tower is sadly obscured by the house built up against it, or rather built into it, for the flues of the chimneys are made to wind in and out of the beautiful recesses and panelling of the tower, in the most barbarous and unsightly manner; no doubt the removal of this monstrous incubus would bring to light several interesting portions of decoration which are now matters of conjecture; at any rate the house should be made to stand clear of the tower, so as to admit of the latter being substantially repaired and restored.

North Side. This side of the tower has suffered least from time or accident; the walls are nearly perpendicular, and the windows and panelling but little deranged on the exterior, but the interior ashlaring is very much shattered in the third story, which clearly proves that the ringing of the bells has been the cause of the dislocated state of the masonry on the inside. The ashlar being but slightly bonded or toothed into the rubble core, has, from the tremulous motion of the bell frame, lost its hold, and is now in many parts a mere upright shell of loose masonry, about 8 or 9 inches thick. This must be taken down and rebuilt, with new bonding stones let into the rubble core from 12 to 18 inches, and pinned up sound in cement.

The weight of the bell frame must also be discharged from this part of the tower, by the introduction of stone corbels twenty-five feet lower down the walls, with strong oak bearing posts introduced to carry the ends of the beams which now support the bell-frame; the parapet and coping must be taken down and rebuilt in stone-work, a considerable portion of it having been very slovenly repaired with bricks.

The weather tables, string courses, and portions of the panelling require to be repaired, and the defective joints soundly stopped in with a strong cement, made to correspond in colour with the original mortar joints.

The shaft and the staircase turret at the north-west angle of the tower above the lead gutters, should be restored in stone, and finished with a stone capping, instead of the present lead and timber covering.

The present roof is new, and not badly constructed as a cover to the tower; but there is a great superfluity of old oak timber under it, which it would be advisable to remove; a cast iron chain tie should be introduced under this roof, as shown in the drawings Nos. 5 and 6.

The modern bell turret which surmounts the roof should be removed; it is quite out of character with the design of the tower.

The lead gutters are in a very defective state; they should be taken up, and new gutters formed with brickwork, smoothly overcoated with Hamelin's cement, and covered over with eight pound milled lead, and five pound flashings, run in with lead. Stone gurgoyle heads or water shoots projecting from the walls, should be introduced to carry off the water from the roof.

The old oak beams, which form the timber work of the guard chamber floor, are many of them rotten at the ends, and sunk down in the middle; the oak plates on which they rested at the back of the ashlar are entirely decayed; I should recommend this floor to be taken down, and a new timber floor of a Norman pattern introduced, the ends of the beams to rest on plates and stone corbels, instead of going into the walls. The cavity formed in the wall by the rotting of the old oak plates, should be carefully pinned up with stone work. See drawing No. 6.

The windows in the second and third stories are calculated to be glazed in cast-iron frames of a Norman pattern; the upper or bell-chamber story to have cast-iron louvres of a proper pattern, and painted bronze green. See drawing No. 7.

Having given the general heads of the works required to be performed in substantially repairing the walls, and restoring the defective mouldings and ornaments of this beautiful fabric, in a substantial and correct manner, I have much pleasure in stating that there is still sufficient stamina in the walls of the building to warrant its being done with perfect safety. I am also of opinion, that the introduction of the cast-iron chain ties, &c., as proposed, will effectually resist any motion occasioned by the ringing of the bells, and that the tower will be perfectly safe for many centuries to come. I beg further to state, that I have carefully digested the plan of operation I should recommend in carrying out the repairs and restoration required, and having ascertained the price of the materials to be used in the several works, as well as the labour and machinery, I am of opinion that the whole may be performed for the sum of £2370.

(*Signed,*) L. N. COTTINGHAM.

SCIENTIFIC SOCIETY.

At the ordinary meeting of this Society, held on Wednesday, 18th January, 1843, John Stevens, Esq., president, in the chair, Dr. Aldis was elected a member, and a beautiful series of squared specimens of granite and oolite building stones was presented to the museum.

The first portion of an essay on "the Alluvium of the Bedford Level," by C. B. Rose, Esq., F.G.S., was submitted, which entered into the archæological particulars of that vast district termed "Marshland,"

the geological structure, and the evidences of the age of the silt deposit of which it is composed.

The first portion comprised an interesting description of the evidences yet remaining of the first system of embankments undertaken at the period of the Roman invasion, by which this district was first drained, and raised above the level of the ocean.

Next in succession were a series of sections and borings, by which the thickness of the alluvium was proved at different points; then a curious examination into the lignite found in this deposit, and a consideration of the causes by which these forests, whence it was so abundantly derived, were destroyed.

The above were the most interesting points in the first portion of Mr. Rose's essay.

A paper was then read "On a proposed New Construction of Chimneys," by James Moon, Esq., Architect. It was stated that, as the cleansing of chimneys by boys was abolished, there is no necessity for flues to be of the present large rectangular form, being ill-adapted for the emission of smoke or cleansing under the recent regulations.

The flues are proposed to be circular, and of three sizes, viz.: for kitchens, general rooms, chambers, and minor rooms, they are to be formed of moulded bricks to work in and bond with the general brickwork, within the thickness of the walls; the gatherings at the openings to be contracted, and the shaft to terminate with a cap contrived to divert the wind. Every flue is perfect in itself, composed of few bricks, and so strong that a wall is not diminished in strength by a series of three flues; their adaptation in party-walls was shown under the impression (which is much required,) that the Building Act is about to be revised.

Mr. Stevens and other gentlemen having made several inquiries of Mr. Moon of a technical and professional character, the former expressed himself pleased that the matter had been taken up by one of the profession, and thought that Mr. Moon's invention was well worthy the attention of builders.

INSTITUTE OF BRITISH ARCHITECTS.

Dec. 19.—J. Shaw, Esq., in the chair.—The Chevalier Bunsen and M. Renard, of Tournay, were elected Honorary Members.—Mr. Fowler, Hon. Sec., on presenting a plan of Hamburg, from M. Chateuneuf, mentioned, as a gratifying circumstance, that our countryman, Mr. Lindley, the engineer, had been appointed by the Senate to superintend in part the rebuilding of the city.—Mr. George Godwin read a paper, illustrated by drawings, on Tournay Cathedral, described as one of the most interesting buildings in Belgium, whether regarded as a specimen of the architectural skill of two different periods of time, or as recalling by association the events of many ages. In form it is a Latin cross, with five towers, namely, two at each end of the transept and one at the centre of the cross. The transept is terminated, both north and south, by a semi-circular absis, similar to many churches in Cologne and other parts of Germany. The nave has an aisle on each side, separated by piers and small columns, bearing semi-circular arches, which in various parts approach the horse-shoe form. Above these is a second range of piers and arches of similar or greater height than the first, forming the front of a large gallery, extending the width of the aisles. Painting and gilding have been extensively used throughout the building. M. Dumotier, one of the government commission appointed to restore the Cathedral, has published two pamphlets, to prove that the nave and transepts are as old as the sixth century. Mr. Godwin showed by analogy, as well as by reference to a manuscript lately discovered, that it was not older than the eleventh century. The choir was rebuilt at the end of the twelfth century and beginning of the thirteenth, and is a fine example of pointed architecture. Until very lately the triforium of the choir and many decorative portions of the building were bricked up and obscured, the paintings were covered with whitewash, and the sculptured capitals were disfigured. £20,000, however, have been voted for its restoration, and the works are now proceeding rapidly. The length of the cathedral within the walls is about 420 feet; the width of the nave, including the aisles, 70 feet; the height of the choir 110 feet. As a datum for comparison, Salisbury Cathedral is 30 feet longer, 8 wider, and 29 lower.

January 23.—T. L. Donaldson, Esq. in the chair.—Among the donations was a fac-simile of an autograph letter of Inigo Jones. The chairman apologized for the unavoidable absence of J. Britton, Esq., who was to have communicated a paper 'On the Design, Ornaments, and peculiar Architectural Characteristics of the South Porch of Malmsbury Abbey Church, with notices of other remarkable Porches of the Middle Ages.' Mr. Britton, he regretted to say, was also unable to send either his paper or the drawings connected with it. They should therefore proceed with the other communication selected for that evening, viz.

"The Report of a Committee of the Institute upon the remains of colour discoverable upon the Xanthian marbles recently brought over by C. Fellows, Esq." The examination of these marbles gives some hope that the question of polychromatic decoration may yet be determined. The marbles inspected for this purpose were those composing the 'Harvey Tomb,' a high square monument, around which are bas-reliefs, representing the legends of the daughters of King Pandarus being carried off by the Harpies. This monument, which with the other marbles brought over by Mr. Fellows has been deposited in the British Museum, had been situated on the slope of a hill which led to the town of Xanthus, in Lycia, Asia Minor. Among the bas-reliefs were five figures, male and female, seated in chairs, on which traces of a brownish tint, approaching to red, are perceptible. Upon the head and crest of the helmet of one figure there were remains of bright crimson colours. The committee are of opinion that the appearances are sufficient to warrant the conclusion that the ground throughout of the bas-reliefs was painted blue, so as to give relief to the figures. Some other portions also showed traces of colour, but the rough state of the surface of the marble prevents the character of the sculpture from being ascertained, which, however, does not indicate any similarity to that of the Parthenon at Athens.

The Committee intend to issue a second report on the subject.

The Chairman then stated, that in consequence of Mr. Britton's inability to attend, he had been applied to by the Secretary for a paper, and he would accordingly read one. The subject was the ruins of the city of Ani, in Armenia, and his communication was founded on accounts furnished by Mr. Hamilton, and drawn up by Mr. Hamilton, jun. The principal object that attracted attention, upon entering the ruins, was a large Christian church, in the form of a Latin cross. The roof was perfect, with the exception of the cupola over the centre of the building. The interior consisted of one principal and two side aisles. Its extreme length was 107 feet; the width 66 feet; the style of architecture the early Saracenic, with some admixture of the Byzantine.

In the early ages of Christianity in Armenia there was great severity of character, and a deficiency in strength, in the style of the ecclesiastical architecture. The want of proportion was a great defect, and an inability to adapt with propriety the ornaments which formed the decorations of their churches. Hence the appearance of those buildings was cold and mean: there were no effects of light and shade. This was not the case with the Byzantines, with whom details were sacrificed to general effect. The Armenian structures exhibited more of Arabic than Roman taste. The use of the column was restricted, instead of which they usually employed pilasters.

Of the decorations, which consisted of paintings, there remained now only some traces of the figures of the twelve apostles.

With respect to the pointed arch and the pointed style observed in the East, though there was some difficulty in fixing the precise date when they were first used in architecture, it was, however, certain that they were of eastern origin, since they were known and might be traced in Mesopotamia long before they were known in Europe. They might be observed in eastern buildings of a date previous to the time of Mahomet.

INSTITUTION OF CIVIL ENGINEERS.

On the Construction of the Bridges on the Bolton and Preston Railway.
By A. J. Adie.

This paper, which was written at the request of General Pasley, and by him communicated to the Institution, contains a description of the bridges over the Cowlin Brook, the Lancaster Canal, and the Chorley Road, which alone possess any peculiarity of construction, and they formed the types upon which the other bridges were built.

In Colonel Sir F. Smith's report upon the Cowlin Brook bridge, he advised great attention being paid to the bridge on account of its "unusual slightness, and the badness of the ground upon which

it was founded." The author states that the latter circumstance induced him to design the present proportions of the work, as he wished to reduce the weight of the piers as much as possible; he therefore ventured to deviate from the original design given by Mr. Rastrick, The result has justified his anticipations, as "after the most careful inspection, not a single crack nor a splintered stone can be detected."

The ground where this bridge was to be placed was found to be a rotten and compressible mixture of moss, decayed wood, and sand, with a few large stones; a foundation was made for each pier by driving in piles 20 feet long by 12 inches square; upon these were placed the footing courses of Limerick stone, 8 inches thick; the piers were built hollow, so that the utmost weight placed upon each superficial foot should not exceed 5¼ tons, which the author states to be a light load for ashlar work:—"In Edinburgh there are old rubble walls 34 inches thick and above 100 feet high, which in addition to all their proportion of eight floors, and a roof, have 6¼ tons on each superficial foot of the bottom courses; and there is a brick chimney in Bolton, the bottom courses of which support 8¼ tons on the superficial foot."

The bridge consists of eight arches, each of 30 feet span; the arch stones are 18 inches thick, of hard sandstone from the Whittle hills, except seven courses at the crown, which are from a better quarry at Ackrington, near Blackburn.

The author then mentions, as a precedent for such dimensions, some arches constructed under Mr. Jardine's direction on the Edinburgh and Dalkeith Railway; they were of Cragleith stone, semi-elliptical in form, of 24 feet span, with a rise of 4 feet, or ⅙th of the span; the stones for these arches were 12 inches deep at the springing, and 9 inches deep at the crown; the abutments of one of them are founded on platforms of timber, without piles, resting upon soft plastic blue clay; they have been standing for upwards of ten years, and exhibit no signs of failure. Another arch is also mentioned, constructed by the same engineer, over the South Esk, near Dalkeith, the span of which is 55 feet, and the versed sine 12 feet; the key-stone is 18 inches deep, and the springers 21 inches in depth.

The author objects to placing a mass of earth upon the haunches of the arch, as, from the tremour caused by the passing of the railway trains, the earth has always a tendency to be wedged in between the side walls and to force them out; he therefore left voids above the arch stones, allowing only sufficient weight of masonry upon the haunches, and thus securing the rapid hardening of the mortar; for this latter reason also the walls of rubble-work never much exceed 3 feet in thickness, and they have been found much stronger in consequence.

The railway is carried over this viaduct on longitudinal bearers, 13 inches deep by 6 inches thick, laid on planks 3 inches thick; the bearers and planks are not fixed together with a view to diminish the vibration of the passing trains; this method of laying is stated to be very effective in this respect.

The Lancaster Canal Bridge was originally intended to have been a direct span of 60 feet, constructed of iron, but the directors subsequently decided on building a skewed stone arch of 25 feet span on the right angle. The arch is semi-elliptical on the square, with a transverse axis of 41 feet 2 inches, and a semi-conjugate axis of 8 feet 9 inches; the arch-stones are 2 feet 3 inches on the square at the springing, and 1 foot 6 inches at the key-stone; the bed joints intersect at right angles all the lines of sections of the intrados, made by vertical planes parallel to the elevation; and it is that property that causes the chamfer lines of the beds of the stones to diverge from the springing to the crown. These lines of the curved joints are easily laid down on the sheeting of the centres from a full-sized development, and by lines drawn at different heights, parallel to the springing of the arch. The lines of the radiating bed joints are always perpendicular to the tangent of an ellipse of the same form as the elevation of the bridge, the moulds used to form this being applied in the plane of the elevation. The twist on the length of the beds of the courses was taken from full-sized skeleton moulds of the form of the oblique ellipse or elevation. The five courses running parallel to the abutments are all of the same form, and have the same amount of twist on the beds of each stone, except the end stones of the courses, which are varied in length to suit the general breaking of the joints of the courses resting together. The centre part of the arch is plain square work.

This mechanical method of finding the lines, and the twist of the radiating beds for an elliptical skewed arch, is destitute of the scientific accuracy of the mode by which Mr. Buck calculates his spiral lines for oblique bridges, of which the section at right angles to the abutment is an arc of a circle; but the workmen had no difficulty in putting it in practice, and the author states that he would have had more trouble in constructing trussed centres for a flatter curve of a circular arc, and at the same time keeping the towing path of the canal open. He states that he had not met with any description of an arch executed in this manner, but he considers it the only true principle. Every very thin section parallel to the elevation is a proper elliptical arch, and there is a very great saving of stone from the smallness of the twist on the curved beds as compared to the common method of working them.

The Chorley Road Bridge is a compound of the common and skewed arches, which the author finds convenient and economical. He has executed several upon this plan; they are as perfect as the best common arches, and free from skirting of the soffits of the stones. The section of this bridge at right angles shows a rise of 5 feet, with a span of 25 feet. The springers at this part are 15 inches deep, and the key-stone is 13 inches deep; on the oblique section, or the elevation, the span is 37 feet 9 inches, and the rise 5 feet; the springers are 24 inches deep, and the key-stone is 17 inches deep.

The straight part of the arch is formed with courses about 10 inches on the soffit, and these are turned round in curved lines which are portions of circles, the straight parts of the courses being then tangents, and they cut the lines of the elevations at right angles, so that there is no more tendency of the arch to sink at the elevation than would be the case with any elliptical segment of similar dimensions worked in the ordinary way. The part of the acute angle of the arch is formed with courses which converge from the elevation to the abutments, on account of being arcs cutting the elevations at right angles, and then becoming nearly tangential at the springing. The curves for these courses were transferred from the developement to the sheeting, in the same way as those for the Lancaster Canal Bridge, and the twist of the beds was taken off full-sized sections of the arch, made in the directions of the converging lines of the extremities, so that at each of these places the beds were worked as if for part of a true elliptical arch, and the beds between the points thus formed were worked off with curved rules found from the developement. After the masons got into the way of working this kind of arch, they of their own accord preferred it to the complete skewed arch. In brick-work built in this way, it would be very easy to skew the ends of a long archway by having the bricks moulded to the curvature of the key-course, as with a very little alteration they would fit any part of the concentric courses, and a few tapered bricks would facilitate the filling up of the fan-shaped part of the haunch of the acute angle.

The communication was illustrated by several detailed drawings, and a model of the bridge, with schedules of the prices and cost of the works.

BLASTING OF THE ROUND-DOWN CLIFF.

Dover, Jan. 26, 5 P.M.

You will not be surprised to hear that the annunciation that an explosion of 18,000lb. of powder was to be made in the Round Down Cliff this afternoon brought an influx of strangers into this town; still, though considerable, it was not so large as I had expected. Curiosity was, I think, paralyzed by a vague fear of danger, which kept some thousands at home who might have witnessed it, as the event turned out, without the slightest shock to their nervous system. The experiment succeeded to admiration, and, as a specimen of engineering skill, confers the highest credit on Mr. Cubitt, who planned, and on his colleagues who assisted in carrying it into execution.

Everybody has heard of the Shakspeare Cliff, and I have no doubt that a majority of your readers have seen it. I should feel it a superfluous task to speak of its vast height, were not the next cliff to it, on the west, somewhat higher. That cliff is Round Down Cliff, the scene and subject of this day's operations. It rises to the height of 375 feet above high-water mark, and was, till this afternoon, of a singular bold and picturesque character. To understand the reasons why it was resolved to remove yesterday no inconsiderable portion of it from the rugged base on which it has defied the winds and waves of centuries, I must make your readers acquainted with the intended line of railroad between Folkstone and this place.

At Folkestone there will be a viaduct of great height and length Then there will be a tunnel, called from a martello tower near it, the Tower Tunnel, one-third of a mile in length. Then comes a cutting through the chalk of two miles in length, called Warren's Cutting. Then comes the Abbott's Cliff Tunnel, one mile and a quarter in length, and now half finished, although only commenced on the 16th of August last. From the Abbott's Cliff tunnel to the Shakspeare Cliff Tunnel the railroad will be under the cliffs close to the sea, and protected from it by a strong wall of solid masonry two miles long, and with a parapet of such a height as will not preclude passengers from the splendid marine

view which lies under them. Now it was found that when a straight line was drawn from the eastern mouth of the Abbott's Cliff Tunnel to the western mouth of the Shakspeare Tunnel, there was a projection on the Round Down Cliff which must be removed in some way or other to insure a direct passage. That projection, seen from the sea, had the appearance of a convex arc of a circle of considerable diameter. It is now removed, and some idea of its size may be formed from the fact that a square yard of chalk weighs two tons, and that it was intended by this day's experiment to remove one million tons. The Shakespeare Tunnel is three-quarters of a mile long, and it is about the same distance from that tunnel to the town of Dover.

Having premised thus much as to the locality of Round Down Cliff, I now proceed to describe, as briefly as I can, the means employed to detach from it such an immense mass of solid matter. Three different galleries, and three different shafts connected with them, were constructed in the cliff. The length of the galleries or passages was about 300 feet. At the bottom of each shaft was a chamber, 11 feet long, 5 feet high, and 4 feet 6 inches wide. In each of the eastern and western chambers 5,500lb. of gunpowder were placed, and in the centre chamber 7,500lb., making in the whole 18,500lb. The gunpowder was in bags, placed in boxes. Loose powder was sprinkled over the bags, of which the mouths were opened, and the bursting charges were in the centre of the main charges. The distance of the charges from the face of the cliff was from 60 to 70 feet. It was calculated that the powder, before it could find a vent, *must* move 100,000 yards of chalk, or 200,000 tons. It was also confidently expected that it *would* move one million tons.

The following preparations were made to ignite this enormous quantity of powder:—At the back of the cliff a wooden shed was constructed, in which three electric batteries were erected. Each battery consisted of 18 Daniels' cylinders, and two common batteries of 20 plates each. To these batteries were attached wires which communicated at the end of the charge by means of a very fine wire of platina, which the electric fluid, as it passed over it, made red-hot, to fire the powder. The wires covered with ropes were spread upon the grass to the top of the cliff, and then falling over it were carried to the eastern, the centre, and the western chamber. Lieutenant Hutchinson, of the Royal Engineers, had the command of the three batteries, and it was arranged that when he fired the centre, Mr. Hodges and Mr. Wright should simultaneously fire the eastern and western barriers. The wires were each 1,000 feet in length, and it was ascertained by experiment that the electric fluid will fire powder at a distance of 2,300 feet of wire. I forgot to mention in its proper place, and as I have time to correct my letter, I may as well mention it here, that after the chambers were filled with powder on Tuesday last, the galleries and passages were all *tamped* up, as is usually the case in all blasting operations.

It was arranged that the explosion should take place at two o'clock, and, in order that the public might be prepared for it, the following account of the signals to be used was very generally circulated on the ground:—

"January 26.

"1. Fifteen minutes before firing all the signal-flags will be hoisted.

"2. Five minutes before firing one gun will be fired, and all the flags will be hauled down.

"3. One minute before firing two guns will be fired, and all the flags (except that on the point which is to be blasted) will be hoisted again."

Two o'clock came, and the general excitement became intense. At ten minutes past two Mr. Cubitt ordered the signal flag at the directors' marquee to be hoisted, and that was followed by the hoisting of all the rest. A quarter of an hour soon passed in deep anxiety. A maroon was thrown over the cliff, and on its explosion with a loud report, all the flags were hauled down. Four more minutes passed away, two more maroons were fired, and all the flags except that on the point to be blasted were again hoisted. The next minute was one of silent, and breathless, and impatient expectation. Not a word was uttered, except by one lady, who when too late, wished to be at a greater distance. *Galeatum sero duelli pœnitet.* Exactly at twenty-six minutes past two o'clock a low, faint, indistinct, indescribable moaning subterranean rumble was heard, and immediately afterwards the bottom of the cliff began to belly out, and then almost simultaneously about 500 feet in breadth of the summit began gradually, but rapidly, to sink, the earth on which the marquee was placed trembling sensibly under the shock. There was no roaring explosion, no bursting out of fire, no violent and crashing splitting of rocks, and, comparatively speaking, very little smoke; for a proceeding of mighty and irrepressible force, it had little or nothing of the appearance of force. The rock seemed as if it had exchanged its solid for a fluid nature, for it glided like a stream into the sea, which was at a distance of about one hundred yards—perhaps more—from its base, filling up several large pools of water which had been left by the receding tide. As the chalk, which crumbled into fragments, flowed into the sea without splash or noise, it discoloured the water around with a dark, thick, inky looking fluid; and when the sinking mass had finally reached its resting place, a dark brown colour was seen on different parts of it, which had not been carried off the land. I forgot to minute the time occupied by the descent, but I calculate that it was about four or five minutes. The first exclamation which burst from every lip was—"Splendid, beautiful!" the next were isolated cheers, followed up by three times three general cheers from the spectators, and then by one cheer more. These were caught up by the groups on the surrounding downs, and, as I am informed, by the passengers in the steam boats. All were excited—all were delighted at the success of the experiment, and congratulation upon congratulation flowed in upon Mr. Cubitt for the magnificent manner in which he had carried his project into execution.

As a proof of the easy, graceful, and swimming style with which Round Down Cliff, under the gentle force and irresistible influence of Plutus and Pluto combined, curtseyed down to meet the reluctant embraces of astonished Neptune, I need only mention that the flagstaff, which was standing on the summit of the cliff before the explosion took place, remained afterwards standing and uninjured on the fallen *debris*. —*The Times, 27th January*, 1843.

MISCELLANEOUS.

Mr. J. B. Neilson, the Inventor of the Hot Blast.—The patent granted to Mr. John Beaumont Neilson, of Glasgow, expired a few weeks ago, for both England and Scotland. We are glad to find that it has been one of the few which have been eminently successful to the inventor. "Besides being of great national benefit," says the *Mining Journal*, "it has realized a sum of not less than £150,000 to the patentees, and has placed John Beaumont Neilson high in the ranks of the benefactors of, not his country alone, but all mankind, iron being the most useful of all the metals, and its cheap production of immense importance in arts and manufactures, on which the convenience and comforts of life depend. Of no small importance has the economizing of that valuable mineral, coal, been promoted by this discovery. Where formerly nine tons were required in Scotland to make one ton of pig iron, it is now done by two and a half tons, or less; and inferior descriptions of both coal and ore may be used, which before could not be applied; and from this cause, a prejudice has arisen against iron made by hot air, which should be attributed to those ores and coals which produce weak iron, rather than to heated air, which, with proper materials, makes as strong, and even stronger iron than cold air. Even the most prejudiced admit this fact, in the case of iron made with anthracite coal. The experiments of Messrs. Hodgkinson and Fairbairn, made under the direction of the British Association, show this fact in iron from the clay iron-stones, and also the red ores."

Edinburgh.—Among the projected improvements upon the Palace and Park of Holyrood, public attention is now directed to the re-edification of the Chapel Royal, as a matter of the first consequence. Independently of its value as an example of Gothic architecture, this venerable ruin possesses a higher interest as the depository of the relics of the ancient Scottish monarchs; and the Edinburgh papers state that it has long been a reflection upon the country, that a structure devoted to such a purpose should be left in a state of neglect and desolation. They state that the late Government incurred some expense in procuring plans for its restoration, and that it would be most gratifying to the national feeling that these or similar plans should be carried out, as a sequel to her Majesty's late visit to Scotland.

Smith's Wire Rope.—A flat rope, of the extraordinary dimensions of three feet in width by three-eighths of an inch in thickness, capable of raising upwards of 250 tons, is now manufacturing at the works of the patentee at Millwall. This is the strongest power of any rope manufactured on record which has come to our knowledge.

Windsor.—The last stone of the spire of the new Military Church, of which Prince Albert laid the foundation in April last, was fixed on Friday, and the arrangement of the interior is now in progress. The body of the church will be fitted up with open benches, without pews. In addition to the accommodation afforded to the military, there will be about 1,000 sittings for the inhabitants of Windsor and Clewer. The principal feature of this church is the tower, nearly 200 feet high, and surmounted by a spire, of Bath-stone, rising 48 feet. The cost of the building will be about 10,000*l.*, nearly one half of which is already subscribed, Her Majesty and Prince Albert being large contributors. The building is de-

signed by Mr. Blore, and when complete will form a striking object from the Castle and surrounding neighbourhood.

CARMARTHEN.—We learn by the local papers that the marble statue of Diana, executed for the King of Prussia by German artists resident at Rome, and which was on board the galliot stranded on the Cefn Sidan sandbank, has been recovered from the wreck. It appears, from the letter of a correspondent of the *Carmarthen Journal*, that it had a narrow escape from mutilation. The wooden case, part of which was four inches in thickness, had, in consequence of the top being off, become nearly filled with sand. This, added to its own weight, had made it so ponderous, that, not being able to raise it from the hold with the tackle then in the vessel, orders had been given to pull the statute from the case, a process which would certainly have broken it into fragments. Ropes had been actually placed for that purpose under its legs and arms, when Mr. Rees, of Kilmaenllwyd, arrived at the wreck; after consulting with Mr. Mansfield, of Llanelly, as to the possibility of its being raised entire, he gave him directions to let the statue remain for that day, and to bring on the following day the tackle, &c. necessary for raising it in the case. Accordingly, Mr. Kiernan, of Parry Port, sent on the next day his powerful tackle and screw-pump; and, under the directions of Mr. Mansfield, the statue was hauled by horses out of the hold, placed upon two pair of wheels, and conveyed to the storehouse at Pembrey, with the loss of part of a finger only. In addition to this the vessel was freighted with numerous cases of marbles of smaller size, all of which have been recovered without much injury.

CITY ANTIQUITIES.—Amongst the most important works now in progress in the City connected with its improvement is that of the extension of the sewerage through Lad-lane, connected with the main leading sewer in Princes-street. The excavations, which are from 18 feet to 20 feet deep, have, during the last month, exhibited some interesting facts relative to the early history of the City. Some few coins, principally of Antoninus, and a few interesting fragments of Roman and Samian pottery, with household utensils, have been found, but the chief objects of interest have been the discovery of some vestiges of the foundation walls of some old Roman buildings. The most extensive of these was found last week, opposite Mr. Chaplin's, of the Swan with Two Necks, where the excavators arived at a wall composed of flints, about 18 feet below the surface, which was between 5 feet and 6 feet in thickness, and through which they had some difficulty to penetrate. A contiguous line of wall was also found in the excavations for laying the foundation for the extensive warehouses of Messrs. Pickfords, the carriers, which are adjacent; and others have been found in other excavations in the neighbourhood, which lead to the idea that on this spot there formerly stood a castle or other extensive erection. A passage was found between this and another wall running in a parallel line betwixt this and Cateaton-street, about 12 feet apart. At the lower depth was a fine stratum of vegetable mould, evidently belonging to a former garden site, which is further confirmed by the appearance of gravel, apparently for the formation of garden walks, as it is only found in thin layers and in detached portions. Above this was found the site of the formation of the old houses destroyed by the fire of London, the rubbish of which, without the aid of concrete, formed the foundation of the more modern buildings. Opposite the church walls in Cateaton-street, at a depth of about 18 feet, there was found a large quantity of human bones, showing that there existed here a place of sepulture, which must have been coeval with the time of the Romans, from the appearance here also of old foundation walls. In connection with the vestiges of the fire of London in this vicinity, it may be stated that, in St. Paul's Churchyard, at the Goose and Gridiron public house, the room still exists which was used by Sir Christopher Wren as his office, and from which he issued his directions for the re-building of the cathederal and the other improvements in the neighbourhood.

PEWS.—The papers have lately noticed the measures taken by the Bishop of Norwich for the removal of pews, in churches, and for the restoration of the ancient custom of fitting-up the body of the building with open benches. We now find that similar efforts are making by the Bishop of Worcester, and that his lordship, in conjunction with the Archdeacon, has stated to the churchwardens of Trinity Church in this town, that the parish church is equally the property of all the parishioners; that any charge for pews or sittings is decidedly illegal; and a practice which the bishop, as the Ordinary, cannot sanction. In consequence of this communication, the wardens have allotted the pews and sittings indiscriminately to the parishioners on application, and free of any charge.

NEW CHURCH AT SONNING.—Early in the ensuing spring, a new church will be erected at Sonning, near Reading, on a piece of ground given by Lord Sidmouth for the purpose. The estimated cost of its erection is 2,000*l*., and nearly that amount has been already subscribed. Mr. R. Palmer, on of the members for the county, has presented the sum of 200*l*. in aid of the undertaking. The population of Sonning very nearly approaches 3,000, and it is intended that the new edifice shall afford accommodation for about one-fourth of that number.

PENINSULAR STEAMERS.—In the *Times* of the 18th of last month, a letter appeared from some passengers who embarked on board the Liverpool at Southampton, on Saturday, the 7th, and complained of having their lives placed in jeopardy, by being sent to sea in a vessel quite unfit for the service in which she was employed.—"We left Southampton," they say, "at 4 P. M., on Saturday, the 7th of January, and, after much difficulty and a run of about 21 hours, put into Portland Bay on Sunday morning. At 4 A.M., on the same day, the weather being moderate a little, we again put to sea, until we arrived off the Start Point, when we were again compelled to put about, and fortunately ran into Torbay at 12 o'clock on Monday night. At 3 P.M. the next day we again put to sea, and reached Falmouth at 6 o'clock on Wednesday morning. Having taken in a supply of coal and mail bags, we went to sea, hoping our difficulties were over; but, unfortunately, after having run about 60 miles to the southward, we encountered a heavy gale, when the vessel was found totally unable to proceed from want of power, obliging us to return again, when she was found almost unable to move either one way or the other. However, towards the evening, the weather moderating, the captain, in his zeal to promote the interest of his employers, and to convey the mails to their destination, again steered southward; but after a vain attempt of about eight hours found that we were positively making no way, and determined to bear away to the nearest port. In the attempt to do so, the gale increased, when it became a matter of the greatest uncertainty if the vessel would live to reach a port, as she was unable to make one knot in the hour, in short, being little more than a useless log on the water, and leaving the lives of all on board to the mercy of the waves, the able management of her commander, and the hearty exertions of her crew, under Providence, alone enabled the vessel to reach port at half past 4 o'clock this morning.

"In conclusion, we beg to state, that it is our firm belief, that the said Liverpool, from the deficiency of power in her engines, is totally unable to cope with an ordinary gale, much less such as usually prevail in the Bay of Biscay."

This letter is signed by Lieut.-colonel Louis, Captain Rickey, and other passengers.

PLANS AND PROJECTS.—In November last, the following plans were lodged in the office of the Clerk of the Peace, at Durham:—

1. Plan of a railway or tramroad, to be called the Weardale Extension Railway, commencing at or near the terminus of the Crook Branch of the Bishop Auckland and Weardale Railway, near Crook, in the township of Crook and Billy-row, in the parish of Brancepeth, and terminating at the south end of Frosterly Bridge, in the township of Frosterly, in the parish of Stanhope, with a branch therefrom to Bishopley Craggs, all in the county of Durham.—THOMAS STOREY, Engineer.

2. Plan showing the line of three intended deviations in the lines of the Great North of England Railway, or Newcastle and Darlington Junction Railway, which are proposed to be made under the powers of an Act to be applied for in the session of 1843.—T. E. HARRISON, Engineer.

3. Plan of an intended Junction Railway, commencing at the Stockton and Darlington Railway, near the 16¼ mile-post, in the parish of Aycliffe, and terminating in the City of Durham Branch of the Clarence Railway, near the 15¼ mile-post, in the parish of Merrington, all in the county of Durham.—JOHN HARRIS, Engineer.

4. Plan of the lower part of the harbour of Sunderland, showing the situation of the tidal basin, and other works, proposed to be constructed across the river Wear, from Thornhill's quay to the Hamsand, in the parishes of Sunderland and Monkwearmouth, in the county palatine of Durham.—JOHN MURRAY, Engineer.

5. Plan of the Great North of England, Clarence, and Hartlepool Junction Railways, with certain proposed extensions and branches therefrom, to join the Byers Green Branch of the Clarence Railway, and also the Great North of England Railway, or the Newcastle and Darlington Junction Railway, all in the county of Durham.—STEPHEN ROBINSON, Engineer.

6. Plan of the intended Hartlepool West Dock and Railway, and other works, all in the county of Durham.—LEATHER AND SON, Engineers.

7. Plan of the intended Hartlepool West Dock and Railway, and other works, all in the county of Durham.—LEATHER AND SON, Engineers.

*** Nos. 6 and 7 are the same, excepting that the one proposes the entrance to the intended west dock on the south-west side of the tide-harbour, and the other on the north-west side.

HARWICH.—The corporation and inhabitants of this town have addressed a memorial to the Lords of the Treasury, representing the rapid changes which are daily taking place in the harbour, caused by the fall of the cliff called the Beacon-hill, on the western entrance of the harbour; and stating that further and more extensive changes are daily taking place in the southern point of the beach, below Landguard-fort, the point having encroached so far into what was formerly the deep-water channel, that the lights erected but a few years since, at a great expense, are no longer found to be a safe leading-mark into the harbour. They express their belief that these changes arise principally from the removal of stone from the Ordnance shore for the purpose of making cement, many thousand tons being annually removed and converted, with the consent of the Board of Ordnance; so that, in a few years, unless a stop is put to such proceedings, Harwich must inevitably become an island; and the harbour, if not entirely destroyed, will be so much deteriorated and blocked up, as to render it, in a great measure, useless as a harbour of refuge, to the injury and danger of a numerous class of vessels which now resort to it for shelter. They conclude by praying for an inquiry into the statements of their memorial, in order that government may adopt measures for preventing the results to which they refer.

CHURCH ANTIQUITIES.—Some very beautiful remains of Norman decorative architecture have been found embedded in the foundations of the piers of the tower of St. Mary's Church, Nottingham. They are exceedingly fine specimens of the pure Norman style, and the probable date, as inferred from their characteristic ornaments and workmanship, is from the year 1101 to 1150. One of them consists of interlacing bands, studded with the nail-head ornament very commonly found in the pure Norman and transition periods, and ending in foliage: the pointed arches formed by the intersection of the bands or scrolls are also enriched by a graceful leaf: the design of this capital is simple, yet very elegant. The other, which is the most singular, consists of two winged animals with a grotesque human head, which forms the corner of the capital; their tails, which meet in the centre, end in foliage; each of them has two feet, which rest on foliage; the capitals have a square *abacus*, which is 3 feet 1 inch in diameter, and a circular torus neck mould, and from the diameter at this part the circular column or shaft must have been about 2 feet 6 inches; the most perfect capitals were found at the base of the north-west pier, and formed the quoins at the angles of the square footing—they had evidently been inseated directly after the destruction of the ancient edifice, as the crimson distemper colour with which they had been enriched was in most parts quite fresh. The foundation of the south-western pier also contained a mutilated capital, which exhibited some beautiful foliage, and many fragments of zig-zag arch mouldings; also, part of the shaft and base of a clustered column, apparently of early decorated character, probably of the latter part of the reign of Henry III.; it is most likely that the capitals formed part of the nave of the church, and the decorated remains of the choir, which, if this were the case, would appear to have had aisles, from whence we may infer that the ancient edifice was of considerable extent. Many very beautiful specimens of encaustic or inlaid paving tiles were likewise found in the several excavations, indeed a complete series of different ages and design might have been formed had they been collected together. The most common variety is about 5½ inches square, highly glazed, and contains a shield bearing three lions, *Fleur de lis*, &c.; these tiles, as they are the most common, are also of the latest date, and probably formed the original pavement of the present church. Others, which are about 4¾ inches square, appear to be the next in point of age; they have various patterns of elegant foliage and diaper work of lozenges, circles, and quatrefoils, which, when properly fitted, produce beautiful combinations; these we may with safety refer to the decorated period of the middle of the 14th century; they are in general of better workmanship, and have a more even surface than the others. Another variety are 4½ inches square, and have the device of a bell, a key, and a sword, upon the same tile; these he should think are earlier still, but the most ancient, which may be of Norman, or at least not later than the early English period, are 3 inches square, and contain rude designs of a greyhound, and other animals; these are in general much worn, and are of very much ruder design and workmanship than the others.

COPPER MINES IN ARDTEELLY.—We are enabled to state that the rich copper mines of Ardteelly are about to be worked with more vigour than ever. An unfortunate difference that occurred in the company last summer, caused a suspension of operations, and then the retiring of Mr. Cornish, who had the sole management of the affairs of the Kenmare Mining Association as trustee, prevented them from proceeding. R. W. Sievier, Esq., to whom the company have confided the management of the concern, is daily expected at Kenmare, to give directions for the most extensive working of the mines, which have already been resumed, giving employment to hundreds.—*Limerick Chronicle.*

THE TELEMAQUE.—"The Telemaque bubble is at an end. She has been consigned to her sable bed, where for upwards of forty years she had lain, the object of dreaming cupidity. The sacks of gold, the jewelled cases, the massive Cathedral offerings of previous gifts—nay, the far-famed necklace of the unfortunate Marie Antoinette, have all been let gently back again into their snug resting-place, opposite Quille-bœuf, till next year, and so it will go on from year to year, while £100 can be extracted from the gullibility of John Bull; for very few shares have been taken by the French, or in France, except by the English. The only redeeming point has been the talent, ingenuity, and perseverance, shewn by the engineer, in having succeeded in accomplishing the raising of the vessel, which had vainly been attempted by the Government and by private enterprise several times during the last forty years. The people employed in the operation returned here last night, having given up all further attempts for this year, owing, as they say, to the advanced state of the season, although we are favoured with the mildest winter ever remembered—the sun shining bright, and the atmosphere like a May morning. * * * The confiding shareholders must, for the present, be content with twenty planks and one cask of tallow, in lieu of "jewels bright, and riches rare."—*Havre, 14th December,* 1842.—*Correspondent of Morning Post.*

RAPID METHOD OF ETCHING.—A most rapid method of etching on iron or steel, capable of very general application, is as follows:—Warm the metal until it is capable of melting a piece of bees'-wax (etching varnish may be used instead of wax) which must then be carefully rubbed over, so as to form a thin and even coating; allow the whole to cool, and scratch out the design in the common way, with a needle or point; then sprinkle on a little powdered iodine, and at the same time add a few drops of water, with a camel-hair pencil, and work them into a *liquid paste*, which must be moved about over the intended engraving, for a period varying from one to five minutes, according to the depth of lines required to be produced. Afterwards wash the whole in clean water. Persons acquainted with the properties of iodine will readily perceive that the same etching paste, by being kept for a few days, will again acquire the property of dissolving iron. I have thus successfully employed the same materials three or four times. Iodine will, doubtless, at no very distant period, supersede the use of acids for the above purpose, on account of its portability and convenience. To travellers and amateurs who amuse themselves with the delightful art of etching, it will, I think, prove invaluable.—*Chemist.*

LIST OF PATENTS.

SIX MONTHS FOR ENROLMENT.

(Continued from Vol. III.)

Felix Napoleon Target, of Blackheath, gentleman, Leon Castelain, of Back-lane, Shadwell, chemist, and Adolphe Aubril, of Back-lane, aforesaid, artist, for "a new method of refining or manufacturing sugar."—Sealed November 25.

James Smith, of Coventry, pattern drawer and card stamper, for "improvements in weaving ribbons and other ornamented fabrics."—Sealed November 25.

Charles Heard Wild, of Birmingham, engineer, for "an improved mode of constructing floors for fire-proof buildings."—Sealed November 25.

Isham Baggs, of Wharton-street, Middlesex, chemist, for "improvements in producing light."—Sealed November 25.

Frederick Oldfield Ward, of St. Martin's-lane, gentleman, and Mark Freeman, of Sutton, Surrey, gentleman, for "improvements in candlesticks, apparatus, and instruments employed in the use of candles and rush-lights."—Sealed November 25.

Pandia Theodore Ralli, of Finsbury-circus, wine merchant, for "improvements in the construction of railway and other carriages, and in apparatus connected therewith," being a communication.—Sealed November 25.

William Henry Fox Talbot, of Laycock-Abbey, Wilts, esq., for

"improvements in coating or covering metals with other metals."—Sealed November 25

Thomas Mansel, of Birmingham, agent, for "certain improved machinery for cutting or shaping leather, paper, linen, lastings, silks, and other fabrics.—Sealed December 3.

Ebenezer Timmis, of Birmingham, manufacturer, for "certain improvements in apparatus used for arresting the progress of, and extinguishing fires." Sealed December 3.

Edward Cobbold, of Melford, in the county of Suffolk, clerk, Master of Arts, for "certain improvements in instruments for writing or marking, part or parts of which improvements are applicable to brushes for water colour drawing." Sealed December 3.

John Stubbins, of Nottingham, hosier, for "improved combinations of machinery to be employed for manufacturing certain parts of articles in stocking or lace fabrics." Sealed December 3.

Don Pedro Pouchant, of Glasgow, civil engineer, for "a certain improvement or improvements in the construction of machinery for manufacturing sugar." Sealed December 3.

John Sealy, of Bridgewater, merchant, for "an improved tile." Sealed December 3; two months.

Charles Heard Wild, of Birmingham, engineer, for "an improved switch for railway purposes." Sealed December 3.

Thomas Howard, of Hyde, Chester, manufacturer, for "certain improvements in machinery for preparing and spinning cotton, wool, flax, silk, and similar fibrous materials." Sealed December 3.

William Hancock, Jun., of Anwell Street, gentleman, for "certain improvements in bands, straps, and cords for driving machinery and other mechanical purposes." Sealed December 3.

Frederick William Etheredge, of Frindsbury, gentleman, for "certain improvements in the manufacture of bricks, tiles, and other similar plastic substances." Sealed December 3.

William Henry Stuckey, of Guilford Street, esq., for "certain improvements in filtering water and other fluids." Sealed December 3.

William Pope, of the Edgeware-road, ironmonger, for "an improved stove." Sealed December 6.

William Oxley English, of Kingston-upon-Hull, distiller, for "improvements in purifying spirits of turpentine, spirits of tar, and naptha." Being a communication. Sealed December 8.

William Coley Jones, of Vauxhall Terrace, practical chemist, and George Fergusson Wilson, of Vauxhall, gentleman, for "improvements in operating upon certain organic bodies or substances in order to obtain products or materials therefrom for the manufacture of candles and other purposes." Sealed December 8.

William Smith Harris and Septimus Hamel, both of Leicester, cotton-winders and co-partners, for "improvements in the manufacture of reels for reeling cotton and linen thread." Sealed December 8.

William Kempson, of the Borough of Leicester, manufacturer, for "improvements in the manufacture of muffs, cuffs, ruffs, tippets, mantillas, pellerines, dressing gowns, boots, shoes, slippers, coats, cloaks, shawls, stocks, cravats, capes, boas, caps, bonnets, and trimmings for parts of dress." Sealed December 8.

George Purt, of St. Mary-at-Hill, soda water manufacturer, and William Hale, of Woolwich, engineer, for "improvements in producing aerated liquors." Sealed December 8.

Richard Barber, of Leicester, reel manufacturer, for "improvements in the manufacture of boots, shoes, and clogs." Sealed December 8.

John George Bodmer, of Manchester, engineer, for certain "improvements in the manufacture of metallic hoops and tyres for wheels, and in the method of fixing the same for use; and also improvements in the machinery or apparatus to be employed therein." Sealed December 8.

William Edward Newton, of Chancery-lane, civil engineer, for "certain improvements in the construction and arrangement of axles and axle-trees for carriages, carts, and other vehicles used on rail or other roads." Being a communication. Sealed December 8.

William Lomas, of Manchester, worsted spinner, and Isaac Shimwell, of the same place, worsted spinner, for "certain improvements in the manufacture of fringes, cords, and other similar small wares, and also in the machinery or apparatus for producing the same." Sealed December 8.

John Grantham, of Liverpool, engineer, for "certain improvements in the construction and arrangements of the engines and their appendages for propelling vessels on water." Sealed December 8.

James Brown, of Soho, Birmingham, engineer, for "certain improvements in steam engines and steam-propelling machinery." Sealed December 8.

Benjamin Fothergill, of Manchester, machine maker, for "certain improvements in machines called mules and other machines for spinning cotton, wool, and other fibrous substances." Sealed December 8.

Percival Moses Parsons, of Waterloo-road, Surrey, civil engineer, for "certain improvements in steam engines and boilers, and in motive machinery connected therewith" Sealed December 8.

Charles Keene, of New Bond-street, hosier, for "improvements in the manufacture of hose, socks, drawers, gloves, mitts, caps, comforters, and cuffs." Sealed December 15.

William Palmer, of Sutton-street, Clerkenwell, manufacturer, for "improvements in the manufacture of candles." Sealed December 15.

Thomas Cardwell, of Bombay, in the East Indies, merchant, for "improvements in the construction of presses for compressing cotton and other articles." Sealed December 15.

Moses Poole, of Lincoln's-inn, gentleman, for "improvements in dressing mill-stones." Being a communication. Sealed December 15.

Charles Maurice Elizee Sautter, of Austin Friars, in the city of London, gentleman, for "improvements in the manufacture of sulphuric acid." Being a communication. Sealed December 15.

Guillaume Simon Richault, of the Sabloniere Hotel, Leicester-square, editor of music, for "improvements in apparatus for exercising the fingers of the human hand, in order to facilitate their use in the playing of the piano-forte and other instruments.' Being a communication. Sealed December 15.

James Winchester, of Noel street, hatter, for "certain improvements in steam boilers, and in the methods of applying steam or other power to locomotive purposes." Sealed December 15.

Edward Robert Rigby and Charles John Rigby, of Gracechurch-street, brush manufacturers and co-partners, for "an improvement or improvements in the manufacture of certain articles in which bristles have been or are now used." Sealed December 21.

Gabriel Hippolyte Moreau, of Leicester-square, gentleman, for "certain improvements in steam generators." Sealed December 21.

Gabriel Hippolyte Moreau, of Leicester-square, gentleman, for "certain improvements in propelling vessels." Sealed December 21.

John Squire, of Ponghill, Cornwall, engineer, for "certain improvements in steam boilers or generators." Sealed December 21.

Taverner John Miller, of Millbank-street, Westminster, oil merchant, for "improvements in apparatus for supporting a person in bed or when reclining." Sealed December 21.

William Bridges, of Birmingham, button tool maker, for "certain improvements in buttons." Sealed December 21.

Henry Purser Vaile, late of Fleet-street, gentleman, for "improvements in combining mechanical instruments for obtaining power." Sealed December 22.

Joseph Beaman, of Smethwick, Stafford, ironmaster, for "an improvement in the manufacture of malleable iron." Sealed December 22.

William Godfrey Kneller, of Wimbledon, chemist, for "improvements in the manufacture of soda in the evaporation of brine, and in the concentration and manufacture of sulphuric acid." Sealed December 22.

Robert Wilson, manager at the works of Messrs. Nasmyths, Gaskell & Co., at Patricross, near Manchester, engineer, for "certain improvements in locomotive and other steam engines." Sealed December 22.

James Morris, of Cateaton-street, London, merchant, for "improvements in locomotive and other steam engines."—Sealed December 22.

Alonzo Graudison Hull, of Clifford-street, Doctor of Medicine, for "improvements in electrical apparatus for medical purposes, and in the application thereof to the same purposes." Sealed December 28.

Thomas Thompson, of Coventry, weaver, for "certain improvements in weaving figured fabrics." Sealed December 28.

Henry Croseley, of the city of London, civil engineer, and George Stevens, of Limehouse, gentleman, for "certain improvements in the manufacture of sugar, and the products of sugar. Sealed December 28.

Edward Thomas, Lord Thurlow, of Ashfield-lodge, Ixworth, Suffolk, for "an improvement or improvements in bits for horses and other animals."—Sealed December 29.

Benjamin Bailey, of Leicester, frame-smith, for "improvements in machinery employed in the manufacture of stockings, gloves, and other frame-work knitted fabrics."—Sealed December 29.

John Stephen Bourlier, of Sherborn-street, Blandford-square, engineer, for "certain improvements in machinery used in printing calicoes, silks, paper-hangings, and other fabrics," being a communication.—Sealed December 29.

Joseph Rock, jun., of Birmingham, factor, for "improvements in the construction of locks." Sealed December 29.

Henry Samuel Rush, of Sloane-street, mechanic, for "improvements in apparatus for containing matches for obtaining instantaneous light."—Sealed December 29.

Baron Victor de Wydroff, of Bracknell, Berkshire, for "improvements in the construction of railways, and in wheels to run on railways, and in apparatus for clearing the rails."—Sealed December 29.

John Bishop, of Poland-street, Westminster, jeweller, for "improvements in apparatus for portioning steam-power, and also improvements in plugs, cocks, or taps for steam, gases, and liquids."—Sealed December 29.

Crawshay Bailey, Esq., of Nant-y-Glo iron-works, Monmouth, esquire, for "certain improved constructions of railways for tramways and railways."—Sealed January 11.

James Harvey, jun., of Regent-street, goldsmith, for "certain improvements in steam-engines," being a communication.—Sealed January 11.

William Ritter, of 106, Fenchurch-street, gent., for "improvements in crystalising and purifying sugar," being a communication.—Sealed January 11.

Julian Edward Disbrowe Rodgers, of Upper Ebury-street, chemist, for "certain improvements in the separation of sulphur from various mineral substances."—Sealed January 12.

William John Loat, of Clapham, builder, for "an improved mode of constructing floors and roofs."—Sealed January 12.

Pierre Armand Lecount de Fontaine Moreau, of Skinner's-place, Size-lane, for "a certain process or processes of combining clay with some other substances, for the producing of a certain ceramic paste capable of being moulded into a variety of forms, and the application thereof to several purposes," being a communication.—Sealed January 14.

James Harvey, of Bazing-place, Waterloo-road, timber merchant, for "improvements in paving streets, roads, and other places, some of which improvements are his own invention, and others have been communicated to him by a foreigner residing abroad."—Sealed January 14.

William Snell, of Northampton-square, gent., for "improvements in machinery for the manufacture of farina."—Sealed January 14.

Nathaniel Card, of Manchester, candlewick manufacturer, for "certain improvements in the manufacture of candlewick, and in the machinery or apparatus for producing such manufacture."—Sealed January 14.

Henry Hussey Vivian, of Singleton, Glamorgan, Esq., and William Gossage, of Birmingham, manufacturing chemist, for "certain improvements in heating or reducing ores of zink; also, certain improvements in furnaces to be used for reducing ores of zink, part of which improvements are applicable to other furnaces."—Sealed January 14.

James Hamer, of Wardour-street, engineer, for "improvements in propelling vessels."—Sealed January 19.

Thomas, earl of Dundonald, of Regent's-park, for "improvements in rotary or revolving engines, and in apparatus connected with steam-engines, and in propelling vessels."—Sealed January 19.

Joseph Kirkman, jun., of Soho-square, pianoforte manufacturer, for "improvements in the action of pianofortes."—Sealed Jan. 19.

Thomas William Bennett, of Gray's Inn-road, timber-merchant, for "improvements in paving or covering roads, streets, and other ways or surfaces."—Sealed January 19.

Luke Hebert, of Dover, civil engineer, for "certain improvements in machines for grinding, and for dressing or sifting grain and other substances."—Sealed January 19.

William Bates, of Leicester, fuller and dresser, for "improvements in the dressing and getting up of hosiery goods, comprising shirts, drawers, stockings, socks, gloves, and other looped fabrics, made from merino, lamb's wool, worsted, cotton, and other yarns, and in machinery for raising the nap or pile on the same."—Sealed Jan. 19.

Thomas Sunderland, of Albany-street, Regent's Park, Esq., for "improvements in moving floating bodies through water and air, and in accelerating the flow of water, air, and other fluids through shafts, pipes, and other channels."—Sealed January 19.

Uriah Clarke, of Leicester, dyer, for "certain improvements in framework-knitting machinery, and a new kind of framework-knitted fabric."—Sealed January 21.

Frederick Albert Winsor, of Lincoln's-inn-fields, barrister-at-law, for "new apparatus for the production of light," being a communication.—Sealed January 26.

Charles Frederick Bielefeild, of Wellington-street, North Strand, papier-mache manufacturer, "for improvements in suspending or hanging swing looking-glasses, and other articles requiring like movements."—Sealed January 26.

William Palmer, of Sutton-street, Clerkenwell, manufacturer, for 'improvements in the manufacture of candles."—Sealed January 26.

Henry Chapman, of Arundel-street, Strand, for "a fabric for maps, charts, prints, drawings, and other purposes."—Sealed January 26.

Francis M'Getrich, of Ernest-Street, St. Pancras, artisan, and Matthew Bailey Tennant, of Henry-street, Regent's-park, gentleman, for "improvements in apparatus for preventing engines and carriages from going off railways, and for removing obstructions on railways."—Sealed January 26.

Edward Smallwood, of North-lodge, Hampstead, gentleman, for "improvements in covering roads, ways, and other surfaces."—Sealed January 26.

Robert Goodacre, of Ullesthorpe, gentleman, for "certain improvements in weighing apparatus applicable to cranes or other elevating machines, whereby the weight of goods may be ascertained while in a state of suspension."—Sealed January 26.

James Boydell, jun., of Oak Farm Works, Dudley, Stafford, for "improvements in the manufacture of metals for edge tools."—Sealed January 26.

George Parker Bidder, of Great George-street, Westminster, civil engineer, for "an improved mode of cutting that kind of slates, commonly called roofing slates, though sometimes used for other purposes."—Sealed January 26.

William James Greenstreet, of Blackfriars-road, gentleman, for "certain improvements in machinery or apparatus for producing or obtaining motive power.—Sealed January 26.

Joseph Kirby, of Banbury, gentleman, for "improved apparatus for manufacturing bricks, tiles, and other articles from clay, or earthy materials. Sealed January 26.

George Phillips Bayly, of 146, Fenchurch-street, brushmaker, for "certain improvements in brushes." Sealed January 26.

Henry Philips, of Exeter, chemist, for "certain improvements in removing impurities from coal gas for the purposes of light." Sealed January 26

Martyn John Roberts, of Brinycæran, Carmarthen, esquire, for "improvements in dyeing wool and woollen fabrics." Sealed Jan. 16.

William Weild, of Manchester, engineer, for "certain improvements applicable to window blinds and curtains, parts of which improvements are also applicable to doors."—Sealed January 28.

David Isaac Wertheimer, of West-street, Finsbury-circus, for "improvements in calculating machines, which improvements are applicable to purposes where wheelwork is required," being a communication.—Sealed January 28.

John Barrow, of East-street, Manchester-square, engineer and smith, for "improvements in the manufacture and laying of window sashes."—January 29.